Arizona
Department of Transportation

WORKBOOK

for

ASPHALTIC CONCRETE PLANT INSPECTION (Course Number 304)

a training course developed
for the

ARIZONA DEPARTMENT OF TRANSPORTATION
Phoenix, Arizona

by

ROY JORGENSEN ASSOCIATES, INC.
Gaithersburg, Maryland

Last revised by ADOT on August 25, 2003

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Directions To Workbook Users

Asphaltic Concrete Plant Inspection (Course 304) is one course in a series on inspection and quality control for bituminous highway construction. Other courses in the series include:

- Field Sampling and Testing for Bituminous Construction (Course 301);
- Prime, Flush and Tack Coats Inspection (Course 302),
- Chip Seal Coat Inspection (Course 303); and
- Asphaltic Concrete Paving Inspection (Course 305).

This course is designed primarily for highway construction inspection personnel, but it can be used in training other personnel.

This Workbook is to be used in conjunction with discussion sessions with the trainee's instructor or supervisor, and other materials that make up the course. As sections of this Workbook are assigned, each trainee should:

1. read and study the material to review previously presented information and gain additional details;
2. complete the exercises and quizzes as they are provided;
3. check his answers against those provided following the exercise or quiz;
4. review the material as needed to correct and clarify any incorrect answers; and
5. discuss any areas that are still not clearly understood with his instructor or supervisor.

Each trainee is provided with his own copy of this Workbook so that he can write in it and keep it for future reference and review.

This course is based primarily on the standards established in the following Arizona Department of Transportation reference documents:

- the following sections of the *Standard Specifications for Road and Bridge Construction:*
  - 406, "Asphaltic Concrete" (AC);
  - 407, "Asphaltic Concrete Friction Course" (ACFC);
  - 408, "Recycled Asphaltic Concrete" (RAC);
  - 409, "Asphaltic Concrete (Miscellaneous Structural)";
  - 413, "Asphaltic Concrete (Asphalt Rubber)" (AR-AC);
  - 414, "Asphaltic Concrete Friction Course (Asphalt Rubber)" (AR-ACFC);
  - 416, "Asphaltic Concrete – End Product"; and
  - 417, "Asphaltic Concrete – End Product SHRP Volumetric Mix"; and
- the corresponding sections of the *Construction Manual*; and
- "Asphaltic Concrete" Section of Chapter IV of the *Construction Manual*, pages 56-102).

Notes

First Discussion Period
(Introduction and Overview of Plants)

Section One: Introduction

This section briefly reviews the materials used in asphaltic concrete, the contract documents and basic concepts in mix designs.

Asphaltic Concrete Materials

All bituminous mixtures consist primarily of two essential ingredients:

1. aggregates, as the basic “building blocks” of the mix (generally about 95 percent of the weight of the mix); and
2. asphalt cement, as the binder to hold the aggregates together (generally, about 5 percent of the weight of the mix).

Sometimes, other materials are added to the aggregates and asphalt to improve resistance to stripping. These materials include:

- mineral admixture which may be added to asphaltic concrete and may consist of either:
    - portland cement, or
    - hydrated lime.

Contract Documents

There are several types of contract documents which provide the requirements for bituminous mixtures and their component materials. In case of discrepancy or conflict, the order in which they govern shall be as follows:

1. **Supplemental Agreements** provide detailed requirements for a specific project and are the highest authority of the contract documents.
2. **Special Provisions & Addendums** provide additions or revisions to the *Standard Specifications* or contracts on individual projects.
3. **Project Plans** provide detailed drawings, tables, charts, etc., for the project;
4. **Standard Drawings** provide Departmental drawings for repetitive use, showing details to be used where appropriate.
5. **Standard Specifications** provide the most general requirements for all projects.

Basic Design Concepts

Mix designs are developed for specific projects and for specific applications of asphaltic concrete within a project. Consideration must first be given to the overall design of the pavement. Some of the considerations in designing a bituminous pavement are:

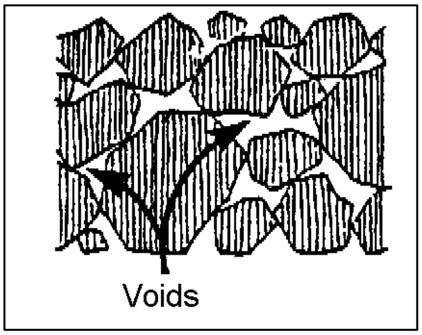
- traffic factors such as the loads, volumes and speed of the traffic;
- the design of the base and any subbase underneath the pavement;
- the functional application for which the mix is to be used including:
  - Asphaltic Concrete used as a leveling course,
  - Asphaltic Concrete used as a surface course, or
  - Asphaltic Concrete Friction Course; and
- such climate factors as moisture, temperatures and the frequency of freezing and thawing.

There also are a number of factors involved in designing the mix itself. Some of the key mix-design factors that you should be aware of as a plant inspector are:

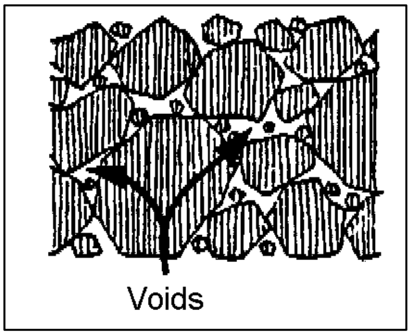
- voids relationships,
- stability, and
- resistance to stripping.

"Voids" are air spaces within the mix. The voids in the mix affect certain properties of the mix and the compacted pavement. You should realize that:

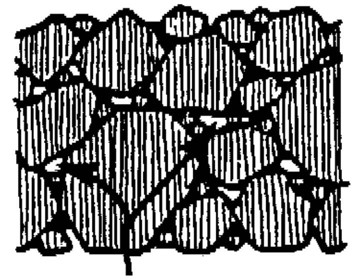
- aggregates by themselves (particularly coarse, angular aggregates) have a relatively high percentage of voids among the particles, even after they are compacted;



- the addition of finer aggregates and mineral admixture reduces the voids by filling some of the spaces; and



- the bituminous binder also reduces the voids, but does not eliminate them.



Effective air voids in the range of 7% at the beginning of a pavement’s life, reduced to around 3% at the end of a pavement’s life, are needed for optimal performance.

If there are too many air voids, they will be interconnected and allow the infiltration of excessive water and air. This condition may result in premature stripping, aging of the asphalt cement, permanent deformation, and fatigue cracking, reducing the overall durability of the pavement.

If there are too few voids, the pavement may exhibit rutting or shoving in the wheel paths or flushing and bleeding on the pavement surface.

Definitions

Voids in the Mineral Aggregate (VMA) are the air-void spaces or pockets of air that exist between the aggregate particles in a compacted mix, including the spaces filled with asphalt. (VMA = effective voids + effective asphalt content.)

Effective Air Voids (EV) are the small air-void spaces or pockets of air that occur between the coated aggregate particles in a compacted mix.

Effective Asphalt Content is the total asphalt content of a paving mixture minus the portion of asphalt that is lost by absorption into the aggregate particles. Only the effective asphalt content is available to serve as a binding medium and a void-filling material in the void spaces between the aggregate particles.

The “**stability**” of the compacted mix is its ability to resist displacement under loads. Displacement or movement of the material under traffic can cause rutting or shoving of the paving. Stability can generally be improved by:

- using aggregates, fine or coarse, which have crushed faces so that the particles interlock with each other, and
- achieving an optimum asphalt content that will bond the particles together (without too much that can excessively “lubricate” the particles or too little that will fail to bond).

“**Resistance to stripping**” refers to the ability of the mix to retain the bituminous coating on the aggregate particles. Water and traffic tend to remove the asphalt coating affecting both the durability and stability of the pavement. Resistance to stripping can be improved by adding mineral admixture to asphaltic concrete.

Based on these and other design considerations, each mix design specifies certain requirements for the aggregates, asphalt cement, any mineral admixture, and the mix itself. As an asphaltic concrete plant inspector, you will not have to develop mix designs, but you must remember that your most important responsibility is to ensure that the mix produced at the plant meets the requirements specified in the mix design.

Section One Quiz

1. Which of the following is sometimes used to improve resistance to stripping in asphaltic concrete? (Circle one or more)

   a. aggregates

   b. asphalt cement

   c. mineral admixture

   d. asphalt cement liquid additive

2. Which of the following is always used in plant-mixed asphaltic concrete? (Circle one or more)

   a. aggregates

   b. asphalt cement

   c. mineral admixture

   d. asphalt cement liquid additive

3. Which of the following may be used as mineral admixture? (Circle one or more)

   a. hydrated lime

   b. clay

   c. portland cement

   d. crushed stone

4. Which of the following materials make up the majority of the weight of any bituminous mix? (Circle one)

   a. aggregates

   b. mineral admixture

   c. asphalt cement

   d. it depends on the mix design

5. Which of the following contract documents provides the most general requirements for all projects? (Circle one)

   a. the Mix Design

   b. the Contract Plans

   c. the *Standard Specifications*

   d. Supplemental Agreements

6. Which of the following contract documents would overrule the others, if there is any conflict among the documents? (Circle one)
    a. the Special Provisions
    b. the *Standard Specifications*
    c. the Contract Plans
    d. Supplemental Agreements

7. Which of the following is the most important responsibility of an asphaltic concrete plant inspector? (Circle one)
    a. developing mix designs
    b. collecting samples
    c. seeing that the mix meets the requirements specified by the mix design

8. Which of the following best describes the desired proportion of voids in mix after it is compacted? (Circle one)
    a. There should be no voids.
    b. There should be a controlled range of air voids over the life of a pavement.
    c. There should be as many voids as possible.

Section One Quiz Answers

1. c. mineral admixture

2. a. aggregates
   b. asphalt cement

3. a. hydrated lime
   c. portland cement

4. a. aggregates

5. c. the *Standard Specifications*

6. d. Supplemental Agreements

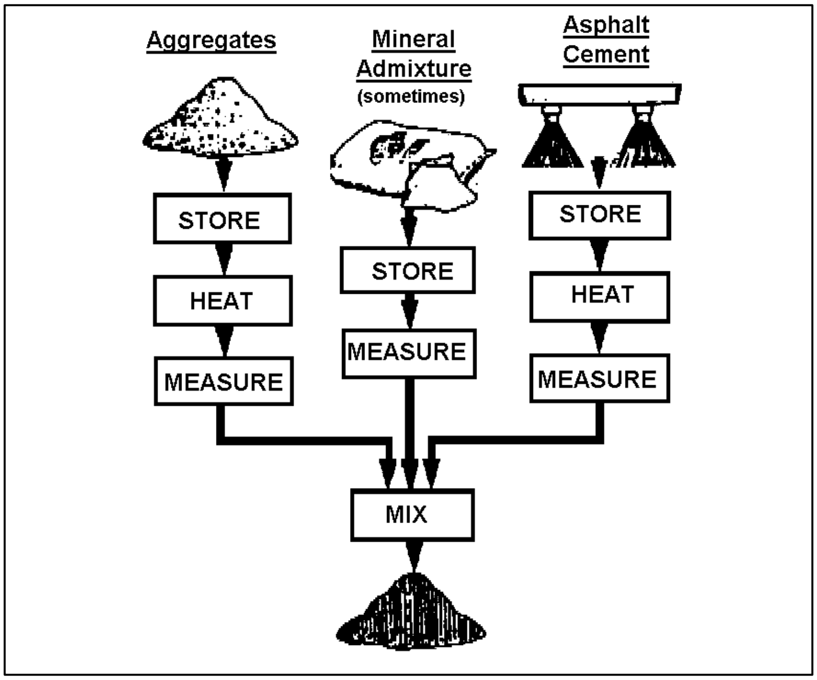
7. c. seeing that the mix meets the requirements specified by the mix design

8. b. There should be a controlled range of air voids over the life of a pavement.

Section Two: Overview of Asphaltic Concrete Plants

The Basic Process

The diagram below illustrates the basic processes involved in producing plant-mixed asphaltic concrete.



Notice that all of the component materials – except mineral admixture which is not heated – go through the same basic functions of storage, heating and measurement.

Types of Plants

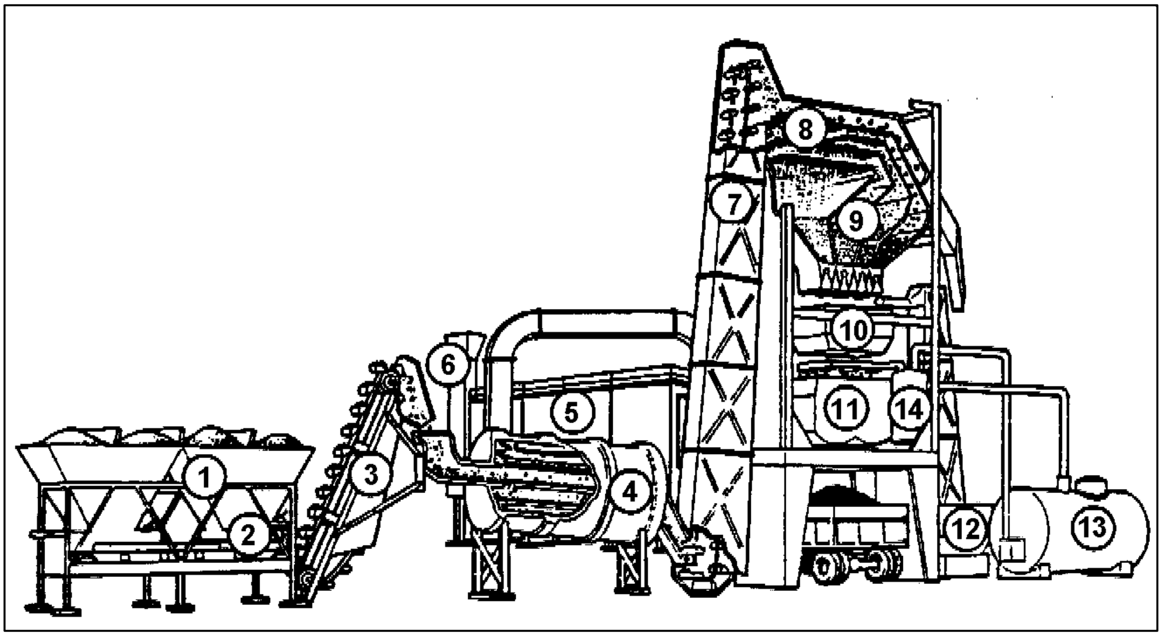
The two primary types[1] of asphaltic concrete plants covered in this course are:

1. batch plants, and
2. drum-mix plants.

[1] A third type – pugmill, continuous-mix plants – is possible, but rarely used now. It is briefly discussed later in Section Four of this Workbook.

Batch Plant Parts and Functions

The basic parts of a typical batch plant are shown in the illustration and outlined below.



Cold Aggregate Supply:

1. Cold Bins
2. Cold Feed Gates & Belts
3. Cold Elevator

Aggregate Heating and Drying:

4. Dryer
5. Dust Collector
6. Exhaust Stack

Aggregate Gradation & Measuring:

7. Hot Elevator
8. Screening Unit
9. Hot Bins
10. Weigh Box

Mixing:

11. Pugmill Mixer

Mineral Admixture Flow:

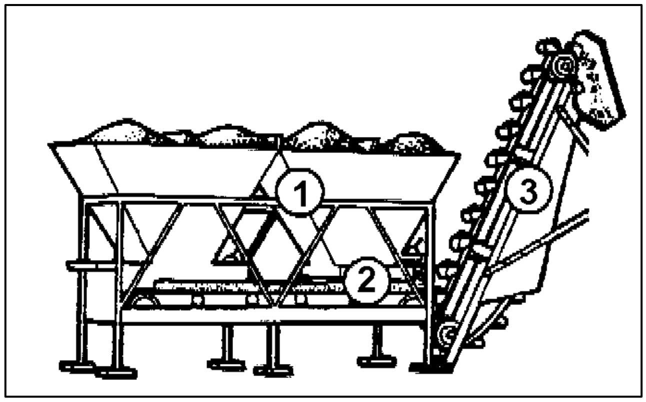
12. Mineral Admixture Storage Silo

Asphalt Cement Flow:

13. Hot Asphalt Storage Tank (and feed line to weigh bucket)
14. Asphalt Weigh Bucket (and spray bars)

The basic functions of these various parts are summarized on the following pages.

Cold Bins (#1)



Aggregates are stored in separate stockpiles, from which they are sometimes transferred to the cold bins. The cold bins keep the aggregates separated (coarse, intermediate and fine).

Cold Feed Gates and Belts (#2)

Each cold bin has an adjustable cold feed gate and belt which measure and feed the appropriate portion of the aggregate onto a conveyor under the cold bins. **This is not the primary measurement of the aggregate**, but it is necessary to avoid imbalances and overloads in other parts of the plant.

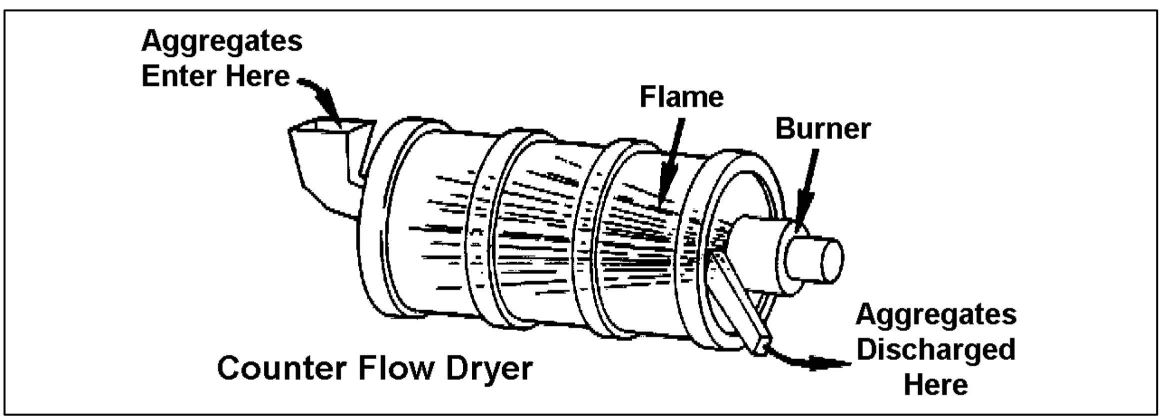
Cold Elevator (#3)

The cold elevator (or cold belt, in some plants) carries the cold aggregate from the cold bins to the dryer. Notice that the different gradations of aggregate have been combined. They will be re-separated later.

Dryer (#4)

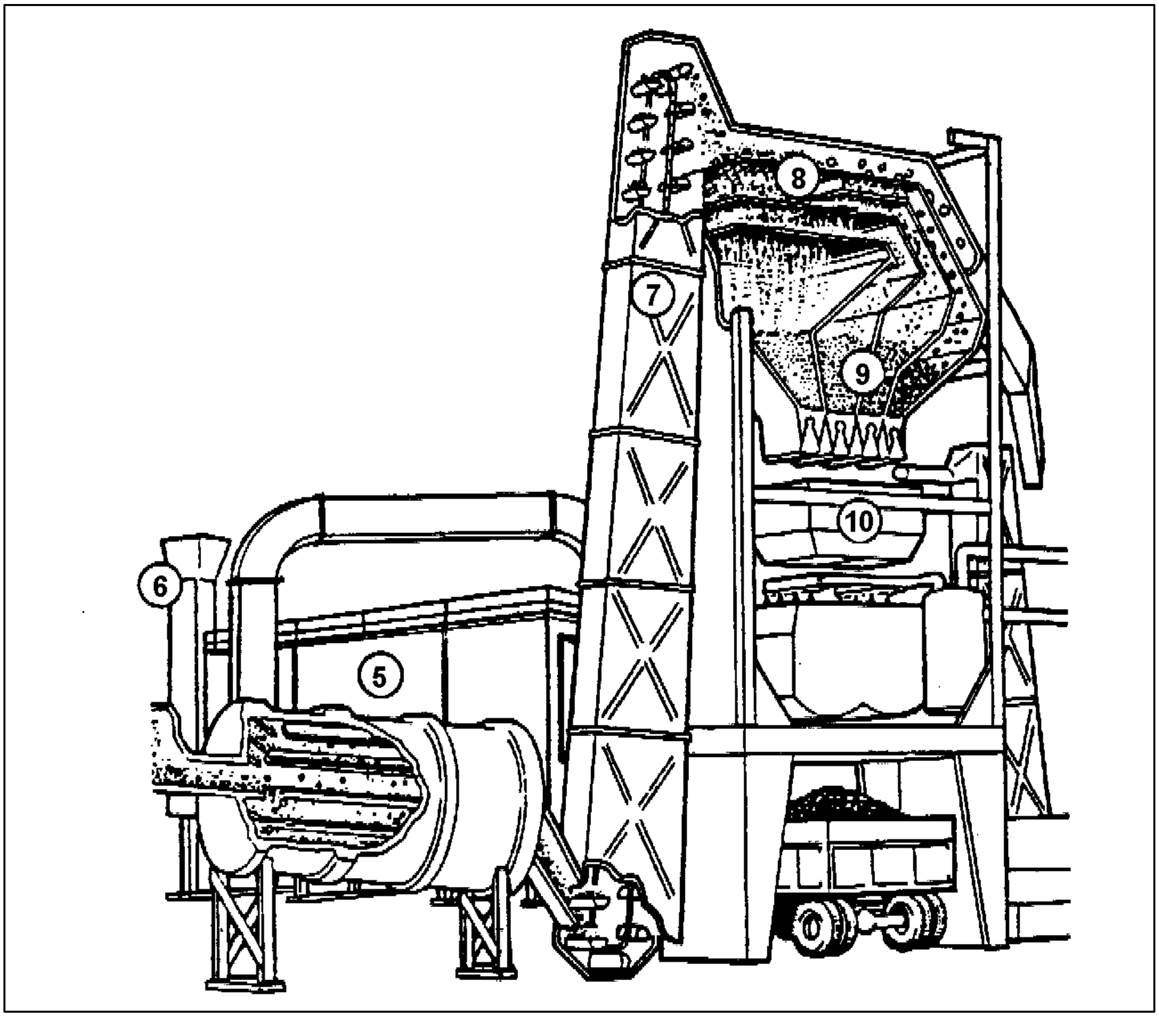
The dryer is tilted at a slight angle so that the aggregates will pass through gradually. The cold aggregates enter at the upper end, pass through the flame from a burner at the opposite end and are discharged through a chute next to the burner.

The flame in the dryer not only dries the aggregate to remove excess moisture, but also heats it so that it will mix well with the hot asphalt.



Dust Collector (#5) and Exhaust Stack (#6)

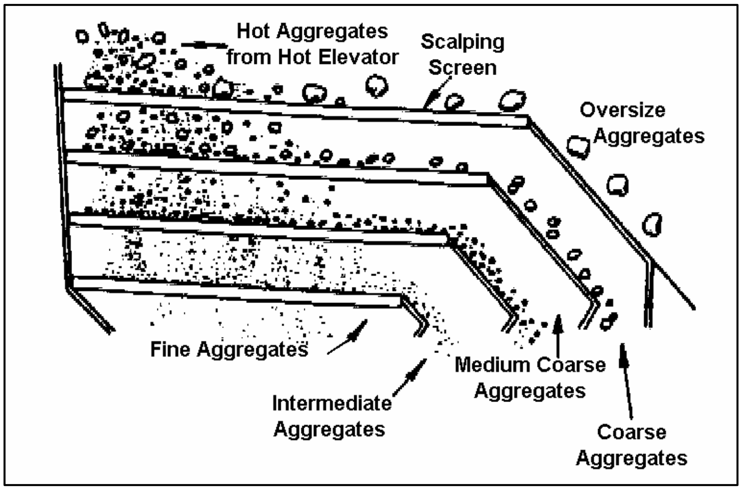
As the aggregates pass through the dryer, the finer material becomes suspended in the hot gases which pass through the dryer to the dust collector. The dust collector removes these fines from the hot gases in order to minimize air pollution. The relatively clean, hot gases are then discharged through the exhaust stack.



Hot Elevator (#7)

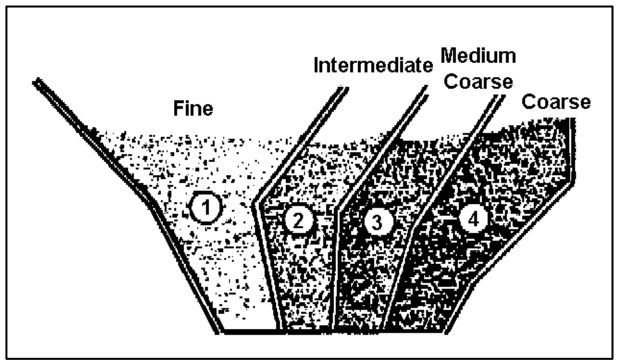
The heated and dried aggregates are discharged from the dryer into the hot elevator which carries them up to the gradation screening unit.

Screening Unit (#8)



The gradation screening unit is a combination of different-sized screens that remove oversized aggregates and re-separate the remaining aggregates into coarse, medium coarse, intermediate, and fine material.

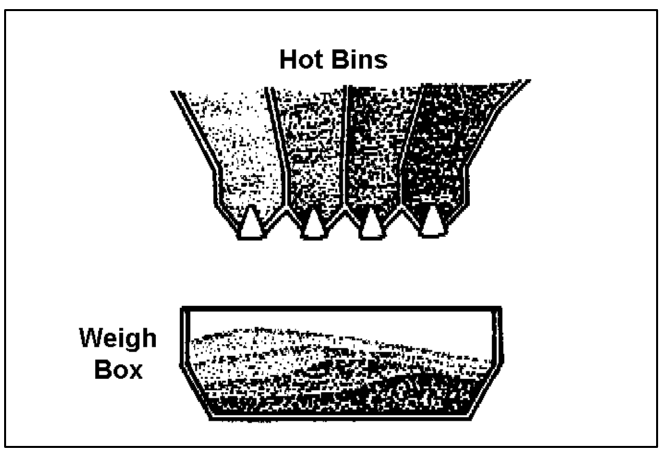
Hot Bins (#9)



The screened aggregates fall into the hot bins which keep them separated and store them until they are ready to be weighed. The bins are numbered from Bin No.1 for the finest aggregates to Bin No. 4 for the coarsest.

Note: The sampling tool is designed to cut the full flow from each bin. Segregation can occur within each bin.

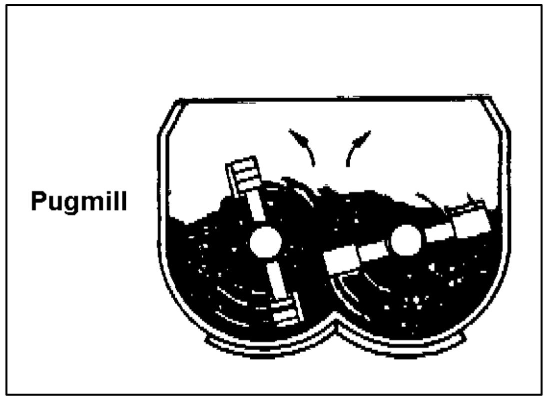
Weigh Box (#10)



Each gradation of aggregate is then discharged from its hot bin into the weigh box where it is weighed to the proper proportions for the mix. This is the primary measurement of the aggregates in a batch plant.

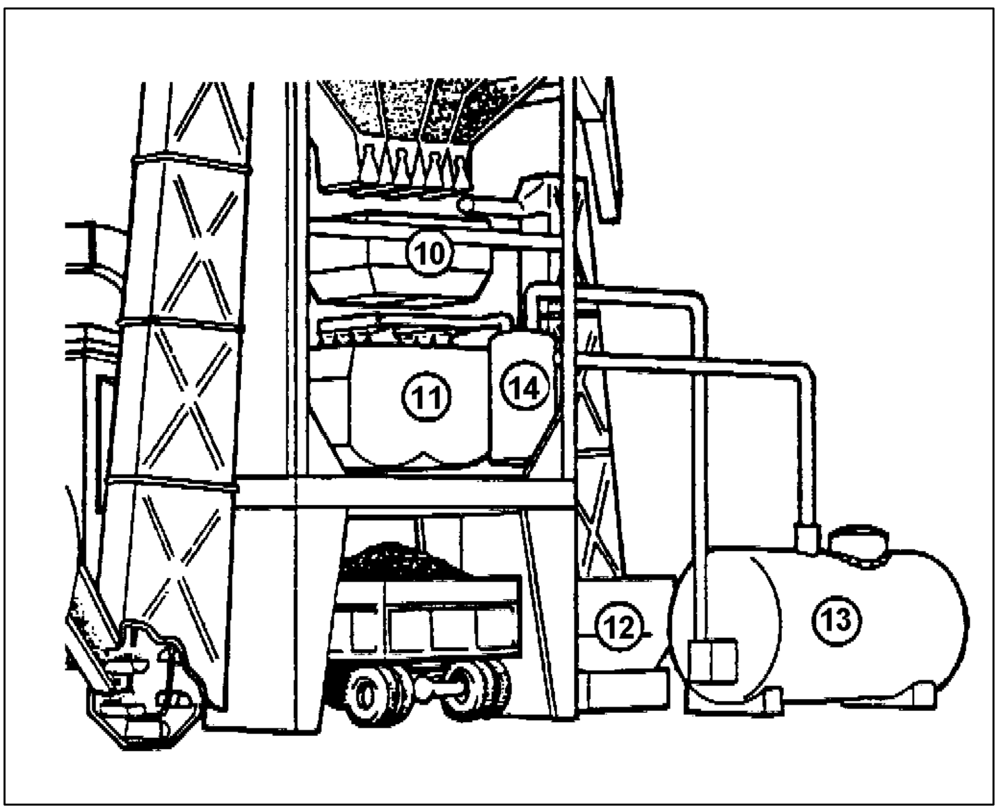
Pugmill (#11)

When the time comes to mix the batch, the weighed aggregates are discharged into the pugmill where they are first "dry-mixed"
with the aggregate to blend the different gradations together and then "wet-mixed" with the asphalt cement.



Mineral Admixture Storage (#12) and Weighing

If mineral admixture is used, it is stored in its own silo or bin, carried by a feed line, and measured, between the coarse and fine aggregates, in the same weigh box used to measure the aggregates. It is first "dry-mixed" with the aggregate then "wet-mixed" with the asphalt cement in the pugmill. See page 47 for information on weighing mineral admixture.



Hot Asphalt Storage (#13)

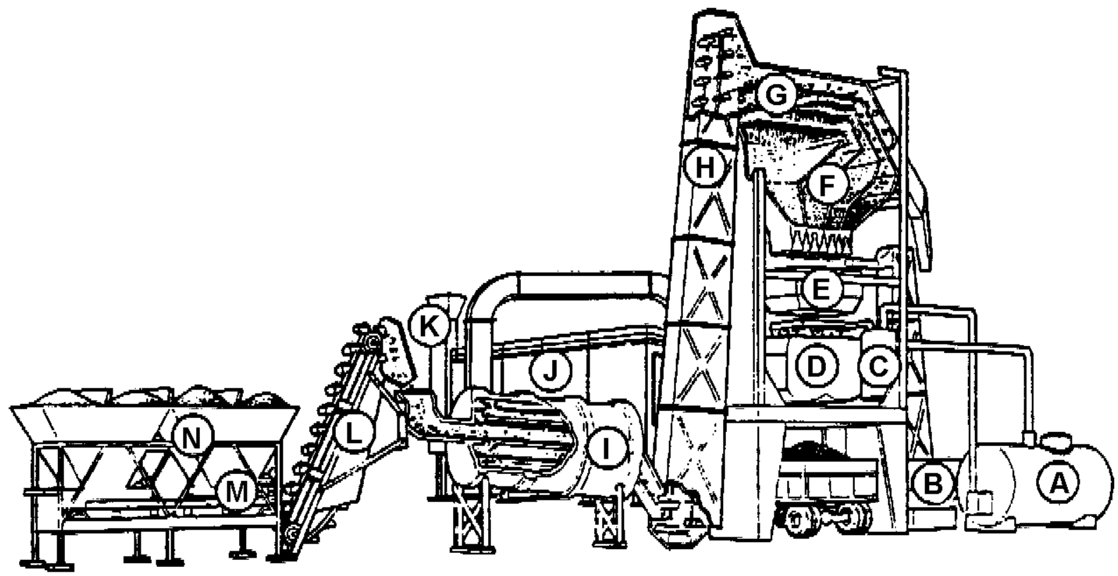
The asphalt cement is stored and heated in an insulated tank. From the tank it is pumped through an insulated feed line to the asphalt weigh bucket. Notice that the illustration shows two lines between the tank and the weigh bucket. The second line recirculates the asphalt to the tank.

Asphalt Weigh Bucket (#14)

The asphalt cement is measured in its own separate weigh bucket. After the various gradations of hot aggregate (and any mineral admixture) have been dry-mixed in the pugmill, the weighed asphalt is discharged through a spray bar or trough into the pugmill for wet-mixing.

Section Two Quiz "A"

Use the diagram below to answer questions 1 through 10.



1. Identify each of the parts of the batch plant labeled in the illustration.

A. ______________________________
B. ______________________________
C. ______________________________
D. ______________________________
E. ______________________________
F. ______________________________
G. ______________________________
H. ______________________________
I. ______________________________
J. ______________________________
K. ______________________________
L. ______________________________
M. ______________________________
N. ______________________________

2. Which of the labeled parts heats the aggregates and removes excess moisture?

____

3. Which of the parts performs the “dry-mixing” of different gradations of aggregates and any mineral admixture?

____

4. Which of the parts removes fines from the hot gases in order to minimize air pollution?

____

5. Which two parts measure the aggregates? ____________ and _____________

6. Which of these two parts (in Question No.5) provides the **primary** measurement of the aggregates? _________________

7. Both “F” and “N” keep aggregates separated by gradation sizes. What is the primary difference between these two parts?

____

8. Which of the parts measures any mineral admixture added to the mix?_________

9. Which of the parts measures the asphalt cement added to the mix? _________

10. Which part removes any oversized aggregates? ___________

Section Two Quiz "A" Answers

1. A. Hot Asphalt Storage
   B. Mineral Admixture Storage
   C. Asphalt Weigh Bucket
   D. Pugmill Mixer
   E. Weigh Box
   F. Hot Bins
   G. Gradation Screening Unit
   H. Hot Elevator
   I. Dryer
   J. Dust Collector
   K. Exhaust Stack
   L. Cold Elevator
   M. Cold Feed Gates and Belts
   N. Cold Bins

2. I

3. D

4. J

5. M and E

6. F

7. In "F" the aggregates are hot, while in "N" they are cold.

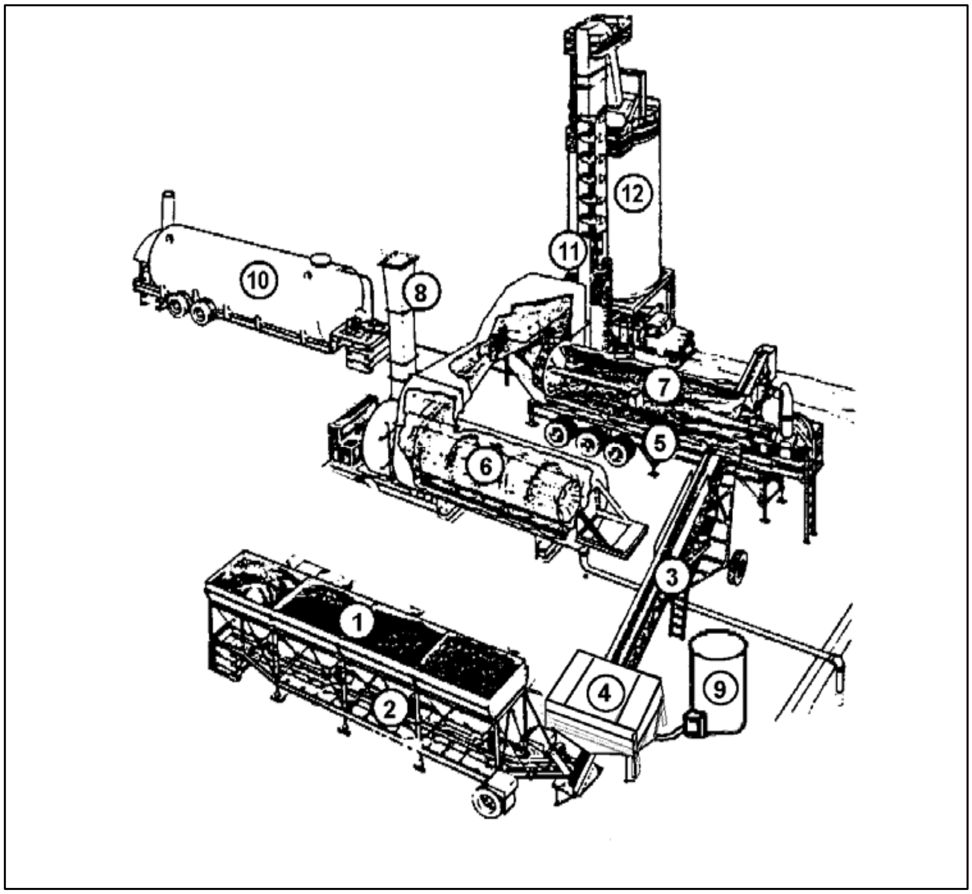
8. E

9. C

10. G

Drum-Mix Plant Parts and Functions

The basic parts of a typical drum-mix plant are shown in the illustration and outlined below.



Cold Aggregate Supply:

1. Cold Bins
2. Aggregate Feed Gates & Belt
3. Cold Feed Belt

Drying and Mixing:

4. Pugmill Mixer
5. Drum-Mixer
6. Dust Collector
7. Minus 200's Return and Pre-Mixer
8. Exhaust Stack

Mineral Admixture Flow:

9. Mineral Admixture Storage

Asphalt Cement Flow:

10. Hot Asphalt Storage Tank (and feed line to drum-mixer)

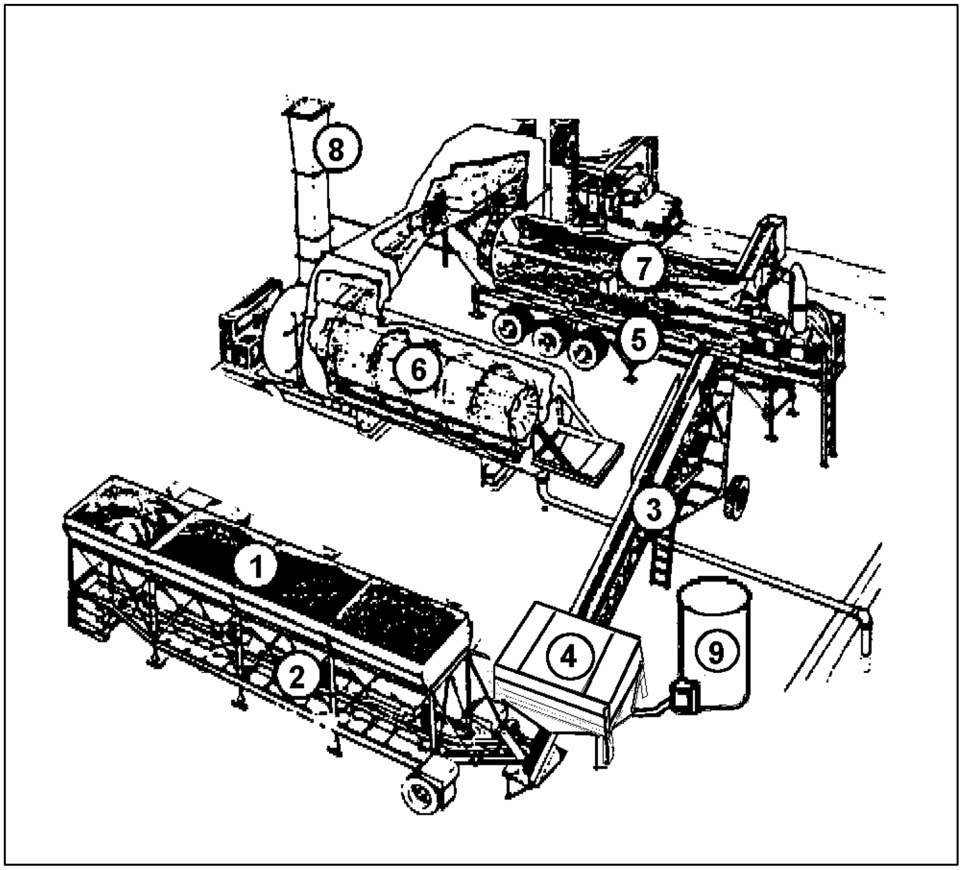
Hot Mix Storage:

11. Hot Mix Elevator
12. Hot Mix Silo

The basic functions of these various parts are summarized on the following pages.

Cold Bins (#1)

The cold aggregate bins in the drum-mix plant are similar to those of a batch plant. The only significant difference is that the gradation and cleanliness of the aggregates in the bins must be even more carefully controlled because the aggregates are not screened later in the process to reseparate the different sizes of material.



Aggregate Feed Gates and Belts (#2)

The feed gates and belts also are similar to those of a batch plant. However, they play a far more important role because they provide the only measurement of the different gradations of aggregate in a drum-mix plant. They must be accurately adjusted to achieve the desired mix design.

Cold Feed Belt (#3)

The aggregate conveyor in a drum-mix plant performs the same type of function as the cold feed elevator in a batch plant – it carries the aggregate from the cold bins to the drum-mixer.

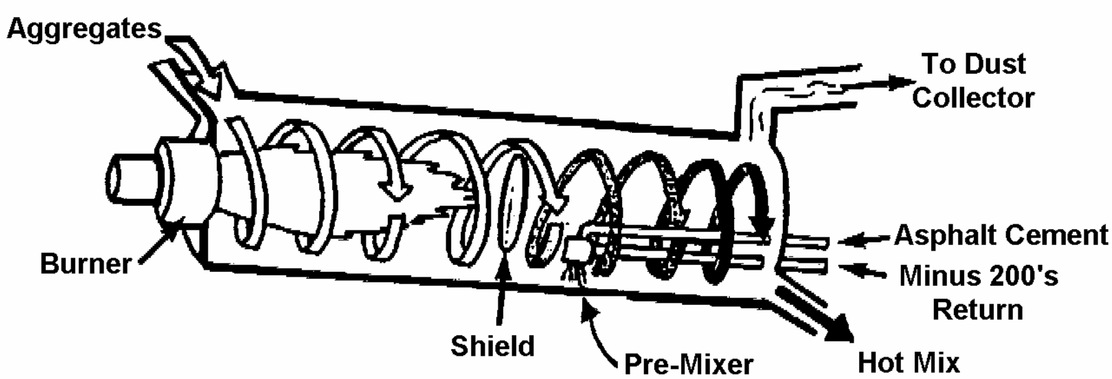
Pugmill Mixer (#4) and Drum-Mixer (#5)

The pugmill mixing system by which the mineral admixture is mixed with aggregates prior to entry into the drum-mixer must be:

- designed to minimize the loss of mineral admixture;
- equipped with a pugmill mixer that is:
  - a pugmill-type mixing device consisting of at least two motorized shafts with mixing paddles,
  - capable of moving the mixture of aggregate and admixture in a near horizontal direction for a distance of at least three feet,
  - capable of effective mixing in the full range of AC production rates,
  - located in the aggregate delivery system at a location where the mixed material can be readily inspected on a belt prior to entering the drum-mixer, and
  - equipped with a water spraying device when required so that the mixture of aggregate and admixture is mixed in a moist state within the pugmill.

The drum-mixer is similar in appearance to the dryer in a batch plant, but it not only heats the aggregates, it also mixes all the materials.

In a parallel flow drum mixer, the aggregates enter at the upper end of the drum-mixer, and the burner is also at this end. In this end of the drum, the aggregates are heated and dried. In the other end of the drum, the asphalt cement is sprayed onto and mixed with the aggregate. Refer to the *Hot-Mix Asphalt Paving Handbook 2000*.



Parallel Flow Drum Mixer

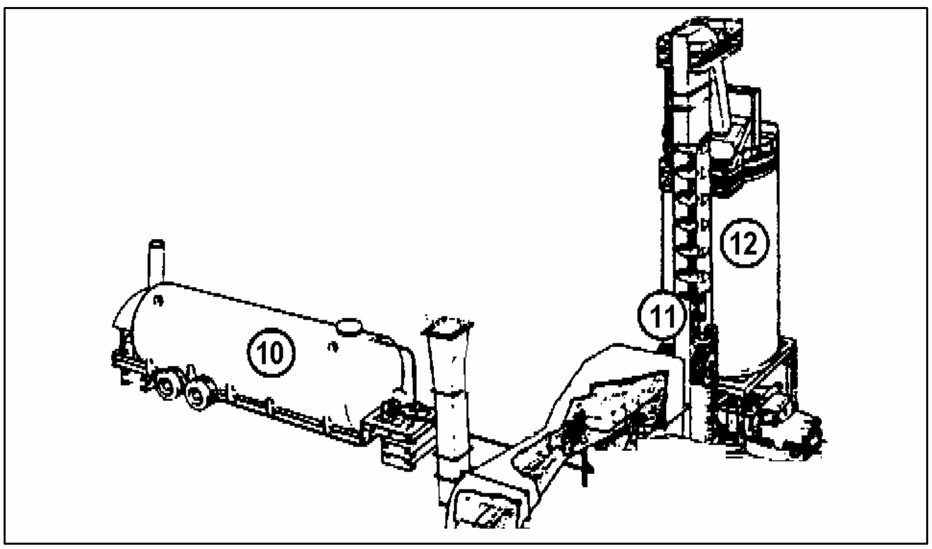
Dust Collector (#6), Minus 200's Return and Pre-Mixer (#7), and Exhaust Stack (#8)

The dust collector and its exhaust stack in a drum-mix plant carry out the same function of removing fines to minimize air pollution as in batch plants. (NOTE: The dust collector shown in the illustration on page 20 is a different type from the one shown for batch plant, but its purpose is the same.)

Mineral Admixture Storage (#9)

When mineral admixture is used, it must be kept dry while in storage. It must be accurately measured by weighing across a weight belt or with a load cell and pre-mixed with the aggregates before asphalt cement is added and mixed together. Mineral admixture shall be pre-mixed with the aggregates by means of a pugmill-type mixing device before the aggregates enter the drum.

This the normal process on ADOT projects, although water also is frequently sprayed on the aggregate prior to or during mixing in the pugmill mixer with the dry mineral admixture. A positive signal system and a limit switch device must be installed which will **automatically shut down the plant** when admixture is not being introduced into the mix.



Hot Asphalt Storage (#10)

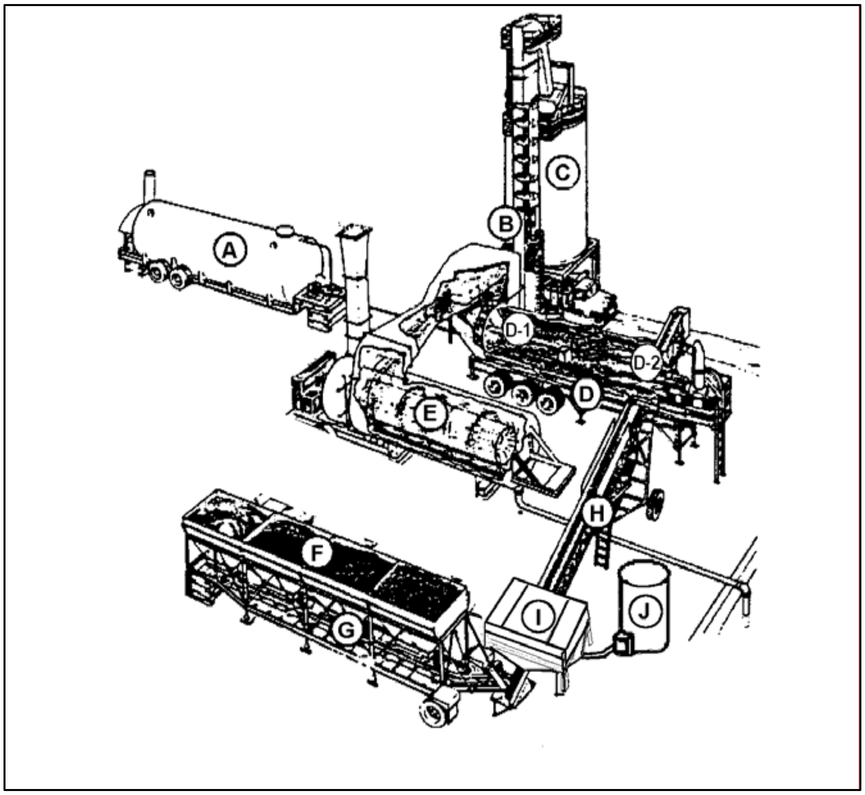
The hot asphalt cement storage tank performs the same heating and storage function as in a batch plant. The key difference is that the asphalt cement is pumped and measured continuously into the mixing end of the drum. So there is no asphalt weigh bucket (just as there is no weigh box for the aggregate).

Hot Mix Elevator (#11) and Silo (#12)

From the drum-mixer, the blended hot mix is discharged into the hot mix elevator and carried up and into the hot mix silo where it is stored until it is discharged into haul trucks.

Section Two Quiz "B"

Use the diagram below to answer questions 1 through 5.



1. Identify each of the parts of the drum-mix plant as labeled with the following letters.

A. ____________________

B. ____________________

C. ____________________

D. ____________________

D-1. ______________ end of the ______________

D-2. ______________ end of the ______________

E. ____________________

F. ____________________

G. ____________________

H. ____________________

I. ____________________

J. ____________________

2. Which of the parts measures the quantities of aggregates for compliance with the mix design? ____________________

3. Which part removes fines in order to minimize air pollution? ____________________

4. At what location is the aggregate heated? ______________________

5. At what location are the aggregates and asphalt cement mixed together?

____

6. If mineral admixture is used, it is normally added ... (Circle one or more)
   a. ... and mixed with the asphalt cement before mixing with the aggregate.
   b. … and mixed with the aggregate before entering the drum-mixer.
   c. … directly into the mixing end of the drum.
   d. ... to the mix after it is discharged from the drum-mixer.

7. Which of the following parts might be found on a batch plant but **not** on a drum-mix plant? (Circle one or more)
   a. cold aggregate feed gates
   b. gradation screens
   c. dust collector
   d. hot aggregate bins
   e. hot pugmill mixer
   f. mineral admixture storage bin or silo
   g. asphalt weigh bucket

Section Two Quiz “B” Answers

1. A. Hot asphalt storage tank
   B. Hot mix elevator
   C. Hot Mix Silo
   D. Drum-mixer
   D-1. Mixing end of the drum-mixer
   D-2. Aggregate heating end of the drum-mixer
   E. Dust collector
   F. Cold bins
   G. Aggregate feed gates and belts
   H. Cold feed belt
   I. Pugmill for mineral admixture
   J. Mineral admixture storage

2. G

3. E

4. D-2

5. D-1

6. b. … and mixed with the aggregates before entering the drum-mixer.

7. b. gradation screens
   d. hot aggregate bins
   e. hot pugmill mixer
   g. asphalt weigh bucket

Notes

Second Discussion Period
(Component Materials Control)

Section Three: Materials Control

Bituminous mixtures – and their component materials – have specific requirements that must be met in order for the mix to be acceptable. Because the quality of the mix can depend largely on the quality of its component materials, effective mix production starts with careful control of the:

- aggregates,
- asphalt cement, and
- any admixtures.

The initial control of these component materials is generally the same for any type of asphalt plant.

Aggregates

Aggregates must be controlled in terms of how they are stockpiled and handled and by sampling and testing.

Stockpiling Aggregates

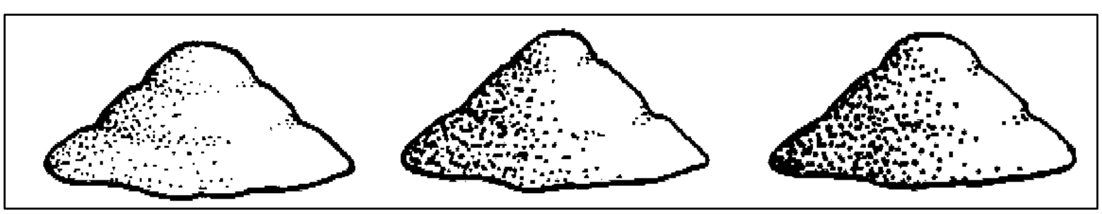
Aggregates are stockpiled in three or four separate gradations of coarse, intermediate, and fine material. The primary objectives in aggregate stockpiling are to:

- avoid contamination from foreign material and intermingling with other aggregate gradations, and
- minimize segregation of aggregates within each stockpile.

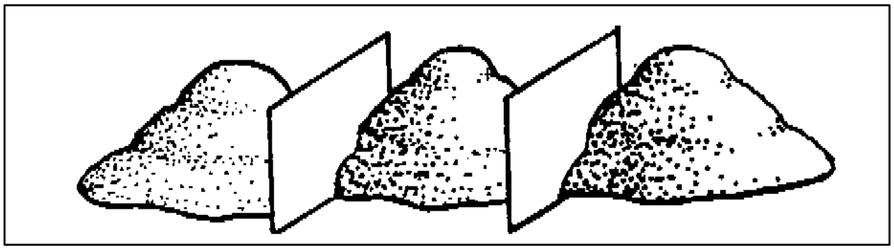
The primary points to watch for when inspecting aggregate stockpiles are as follows:

1. Stockpiles should be placed on clean, dry, level surfaces.
2. Stockpiles should be formed in a manner that eliminates segregation of aggregates.
3. Different gradations of aggregates must be kept separated from each other by providing either:

   a. plenty of space between stockpiles, or



b. bulkheads or partitions between the stockpiles from the bottom to above the tops of the stockpiles.



For 407 ACFC, 413 AR-AC and 414 AR-ACFC mixtures, the contractor also must have sufficient stockpiles of aggregates to provide for at least two days of production, unless the total or remaining production is less than two days.

Handling Aggregates

Wheel loaders are generally used to transfer aggregates from the stockpiles to the cold bins. The loader operator should be careful to avoid contamination and segregation when transferring the aggregates. Dozers and other track equipment should not be used because the pushing force of a dozer tends to segregate the aggregates and the tracks tend to break up the particles into finer gradations.

As a general rule, any handling of the aggregates – from their delivery to stockpiles, to sampling and testing, and to the operation of the plant itself – should be done in a manner that will avoid contamination and minimize segregation.

Aggregates Sampling and Testing

Aggregates used in **bituminous mixtures** need to be sampled and tested for a variety of properties. A separate course, **Field Sampling and Testing for Bituminous Construction** (Course 301), is provided for the sampling and testing procedures involved in bituminous construction.

Asphalt Cement

Asphalt cement must be controlled in terms of its delivery, storage, sampling, and testing.

Delivery of Asphalt Cement

When asphalt cement is delivered to the project, you should check the weight ticket for the load to determine the quantity of material being delivered. This weight can be cross-checked with the scales at the plant or with the weight sheet from the scale house.

Asphalt Storage

The basic storage requirements for asphalt are the same for any type of plant. The asphalt storage tank must:

- have a device for heating the material,
- be insulated to maintain the heat,
- have a pyrometer or thermometer so that temperatures can be accurately monitored, and
- provide a sampling device.

You need to determine the quantity of asphalt cement in the storage tank at the start and end of each day by:

- getting an initial reading in gallons,
  - ➢ measuring the level of asphalt in the tank in inches, and
  - ➢ converting inches to gallons using the tank's calibration chart; and
- adjusting this initial reading using a temperature-volume correction chart, as shown on page 31.

Asphalt Sampling and Testing

At times, you may need to collect samples of the asphalt cement. However, these samples are sent to the District or Central lab for testing.

Admixtures

Mineral admixture must be controlled under the following criterion:

- Portland cement or hydrated lime used as a mineral admixture for asphaltic concrete requires only a certificate of analysis.
- Although no sampling is required by the project for either lime or cement when used as a mineral admixture, they must be stored in an enclosed bin or silo to keep dry.

Note: Always check the "Sampling Guide Schedule" in Series 900, and Series 1000 "Certificates," of the ADOT Materials Testing Manual for the most recent changes, if any, for various criteria involving sampling quantities or certificates.

Temperature-Volume Corrections for Asphaltic Materials

Group 0 – Specific Gravity at 60° F Above 0.966

LEGEND: t = observed temperature in degrees Fahrenheit
M = multiplier for correcting asphalt cement volumes to the basis of 60° F

t	M	t	M	t	M	t	M	t	M	t	M	t	M	t	M	t	M	t	M
0	0.0211	50	1.0035	100	0.9861	150	0.9689	200	0.9520	250	0.9352	300	0.9187	350	0.9024	400	0.8864	450	0.8705
1	1.0200	51	1.0031	101	0.9857	151	0.9686	201	0.9516	251	0.9349	301	0.9184	351	0.9021	401	0.8861	451	0.8702
2	1.0204	52	1.0028	102	0.9854	152	0.9682	202	0.9513	252	0.9346	302	0.9181	352	0.9018	402	0.8857	452	0.8699
3	1.0201	53	1.0024	103	0.9851	153	0.0969	203	0.9509	253	0.9342	303	0.9177	353	0.9015	403	0.8854	453	0.8696
4	1.0197	54	1.0021	104	0.9847	154	0.9675	204	0.9506	254	0.9339	304	0.9174	354	0.9011	404	0.8851	454	0.8693
5	1.0194	55	1.0017	105	0.9844	155	0.9672	205	0.9503	255	0.9336	305	0.9171	355	0.9008	405	0.8848	455	0.8690
6	1.0190	56	1.0014	106	0.9840	156	0.9669	206	0.9499	256	0.9332	306	0.9167	356	0.9005	406	0.8845	456	0.8687
7	1.0186	57	1.0010	107	0.9837	157	0.9665	207	0.9496	257	0.9329	307	0.9164	357	0.9002	407	0.8841	457	0.8683
8	1.0183	58	1.0007	108	0.9833	158	0.9662	208	0.9493	258	0.9326	308	0.9161	358	0.8998	408	0.8838	458	0.8680
9	1.0179	59	1.0003	109	0.9830	159	0.9658	209	0.9489	259	0.9322	309	0.9158	359	0.8995	409	0.8835	459	0.8677
10	1.0176	60	1.0000	110	0.9826	160	0.9655	210	0.9486	260	0.9319	310	0.9154	360	0.8992	410	0.8832	460	0.8674
11	1.0172	61	0.9997	111	0.9823	161	0.9652	211	0.9483	261	0.9316	311	0.9151	361	0.9889	411	0.8829	461	0.8671
12	1.0169	62	0.9993	112	0.9819	162	0.9648	212	0.9479	262	0.9312	312	0.9148	362	0.8986	412	0.8826	462	0.8668
13	1.0165	63	0.9990	113	0.9816	163	0.9645	213	0.9476	263	0.9309	313	0.9145	363	0.8982	413	0.8822	463	0.8665
14	1.0162	64	0.9986	114	0.9813	164	0.9641	214	0.9472	264	0.9306	314	0.9141	364	0.8979	414	0.8819	464	0.8661
15	1.0158	65	0.9983	115	0.9809	165	0.9638	215	0.9469	265	0.9302	315	0.9138	365	0.8976	415	0.8816	465	0.8658
16	1.0155	66	0.9979	116	0.9806	166	0.9635	216	0.9466	266	0.9299	316	0.9135	366	0.8973	416	0.8813	466	0.8655
17	1.0151	67	0.9976	117	0.9802	167	0.9631	217	0.9462	267	0.9296	317	0.9132	367	0.8969	417	0.8810	467	0.8652
18	1.0148	68	0.9972	118	0.9799	168	0.9628	218	0.9459	268	0.9293	318	0.9128	368	0.8966	418	0.8806	468	0.8649
19	1.0144	69	0.9969	119	0.9795	169	0.9624	219	0.9456	269	0.9289	319	0.9125	369	0.8963	419	0.8803	469	0.8646
20	1.0141	70	0.9965	120	0.9792	170	0.9621	220	0.9452	270	0.9286	320	0.9122	370	0.8960	420	0.8800	470	0.8643
21	1.0137	71	0.9962	121	0.9788	171	0.9618	221	0.9449	271	0.9283	321	0.9118	371	0.8957	421	0.8797	471	0.8640
22	1.0133	72	0.9958	122	0.9785	172	0.9614	222	0.9446	272	0.9279	322	0.9115	372	0.8953	422	0.9794	472	0.8636
23	1.0130	73	0.9955	123	0.9782	173	0.9611	223	0.9442	273	0.9276	323	0.9112	373	0.8950	423	0.9791	473	0.8633
24	1.0126	74	0.9951	124	0.9778	174	0.9607	224	0.9439	274	0.9273	324	0.9109	374	0.8947	424	0.8787	474	0.8630
25	1.0123	75	0.9948	125	0.9775	175	0.9604	225	0.9436	275	0.9269	325	0.9105	375	0.8944	425	0.8784	475	0.8627
26	1.0119	76	0.9944	126	0.9771	176	0.9601	226	0.9432	276	0.9266	326	0.9102	376	0.8941	426	0.8781	476	0.8624
27	1.0116	77	0.9941	127	0.9768	177	0.9597	227	0.9429	277	0.9263	327	0.9099	377	0.8937	427	0.8778	477	0.8621
28	1.0112	78	0.9937	128	0.9764	178	0.9594	228	0.9426	278	0.9259	328	0.9096	378	0.8934	428	0.8775	478	0.8618
29	1.0109	79	0.9934	129	0.9761	179	0.9590	229	0.9422	279	0.9256	329	0.9092	379	0.8931	429	0.8772	479	0.8615
30	1.0105	80	0.9930	130	9.7558	180	0.9587	230	0.9419	280	0.9253	330	0.9089	380	0.8928	430	0.8768	480	0.8611
31	1.0102	81	0.9927	131	0.9754	181	0.9584	231	0.9416	281	0.9250	331	0.9086	381	0.8924	431	0.8765	481	0.8608
32	1.0098	82	0.9923	132	0.9751	182	0.9580	232	0.9412	282	0.9246	332	0.9083	382	0.8921	432	0.8762	482	0.8605
33	1.0095	83	0.9920	133	0.9747	183	0.9577	233	0.9409	283	0.9243	333	0.9079	383	0.8918	433	0.8759	483	0.8602
34	1.0091	84	0.9916	134	0.9744	184	0.9574	234	0.9405	284	0.9240	334	0.9076	384	0.8915	434	0.8756	484	0.8599
35	1.0088	85	0.9913	135	0.9740	185	0.9570	235	0.9402	285	0.9236	335	0.9073	385	0.8912	435	0.8753	485	0.8596
36	1.0084	86	0.9909	136	0.9737	186	0.9567	236	0.9399	286	0.9233	336	0.9070	386	0.8908	436	0.8749	486	0.8593
37	1.0081	87	0.9906	137	0.9734	187	0.9563	237	0.9395	287	0.9230	337	0.9066	387	0.8905	437	0.8746	487	0.8590
38	1.0077	88	0.9902	138	0.9730	188	0.9560	238	0.9392	288	0.9227	338	0.9063	388	0.8902	438	0.8743	488	0.8587
39	1.0074	89	0.9899	139	0.9727	189	0.9557	239	0.9389	289	0.9223	339	0.9060	389	0.8899	439	0.8740	489	0.8583
40	1.0070	90	0.9896	140	0.9723	190	0.9553	240	0.9385	290	0.9220	340	0.9057	390	0.8896	440	0.8737	490	0.8580
41	1.0067	91	0.9892	141	0.9720	191	0.9550	241	0.9382	291	0.9217	341	0.9053	391	0.8892	441	0.8734	491	0.8577
42	1.0063	92	0.9889	142	0.9716	192	0.9547	242	0.9379	292	0.9213	342	0.9050	392	0.8889	442	0.8731	492	0.8574
43	1.0060	93	0.9885	143	0.9713	193	0.9543	243	0.9375	293	0.9210	343	0.9047	393	0.8886	443	0.8727	493	0.8571
44	1.0056	94	0.9882	144	0.9710	194	0.9540	244	0.9372	294	0.9207	344	0.9044	394	0.8883	444	0.8724	494	0.8568
45	1.0053	95	0.9879	145	0.9706	195	0.9536	245	0.9369	295	0.9204	345	0.9040	395	0.8880	445	0.8721	495	0.8565
46	1.0049	96	0.9875	146	0.9703	196	0.9533	246	0.9365	296	0.9200	346	0.9037	396	0.8876	446	0.8718	496	0.8562
47	1.0046	97	0.9871	147	0.9699	197	0.9530	247	0.9362	297	0.9197	347	0.9034	397	0.8873	447	0.8715	497	0.8559
48	1.0042	98	0.9868	148	0.9696	198	0.9526	248	0.9359	298	0.9194	348	0.9031	398	0.8870	448	0.8712	498	0.8556
49	1.0038	99	0.9864	149	0.9693	199	0.9523	249	0.9356	299	0.9190	349	0.9028	399	0.8867	449	0.8709	499	0.8552

Section Three Quiz

1. The two primary objectives in stockpiling aggregates are to:

   a. ____, and

   b. ____ .

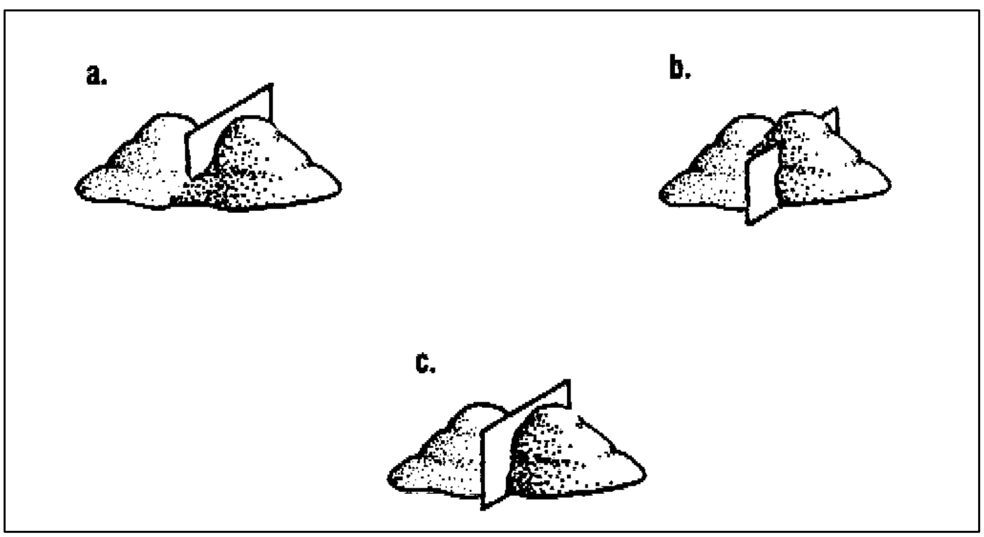
2. In determining the quantity of asphalt cement in a storage tank the reading in gallons must be adjusted using a

   ____

3. At a plant producing asphaltic concrete friction course for ACFC 407, the contractor should have enough aggregate stockpiled for … (Circle one):

   a. four hours of production.
   b. one days production.
   c. two days production.
   d. three days production the entire project.

4. Which of the following diagrams represents the proper use of a bulkhead in separating aggregate stockpiles? (Circle one)



5. Which of the following types of equipment should **not** be used in handling aggregates for mix production? (Circle one or more)

   a. wheel loaders
   b. dozers
   c. any track equipment
   d. all of the above are suitable

6. Which of the following materials must be checked for certification on delivery to the plant? (Circle one or more)

   a. asphalt cement
   b. mineral admixture
   c. mineral aggregate
   d. all of the above

7. Which of the following is not a requirement for the storage tank for asphalt cement?

   a. a heating device
   b. a thermometer
   c. insulation
   d. none of the above – they are all requirements
   e. a, b, and c – none of them are requirements

Section Three Quiz Answers

1. a. avoid contamination
   b. minimize segregation

2. temperature-volume correction chart

3. c. two days production.

4. c.

5. b. dozers
   c. any track equipment

6. a. asphalt cement
   b. mineral admixture.

6. d. none of the above – they are all requirements

Notes

Third Discussion Period
(Inspecting Batch Plants)

Section Four: Inspecting Batch Plants

This section reviews the inspection of batch plants in terms of:

- cold aggregate supply,
- aggregate heating and drying,
- hot aggregate screening and storage,
- weighing aggregates and mineral admixtures,
- weighing asphalt, and
- mixing.

Cold Aggregate Supply

Because we have already discussed stockpiling in the last section, we will start here with inspecting the cold bins, cold feed gates and cold feed belts.

Cold Bins

The primary things to watch for in inspecting the cold bins are:

- that the different gradations of aggregates are placed in the appropriate bins,
- that the partitions between bins are high enough and in good condition to prevent intermingling of the different gradations, and
- that there is no excessive moisture in the aggregates (particularly the fine aggregates) which may cause the material to hang-up and “bridge” over the bottom of the bin.

Cold Feed Gates

The cold feed gate for each cold bin must:

- be adjustable to different openings,
- have a graduated indicator to show the size of the opening, and
- have a locking device to prevent changes in the adjustment after it is set.

Cold Feed Belt

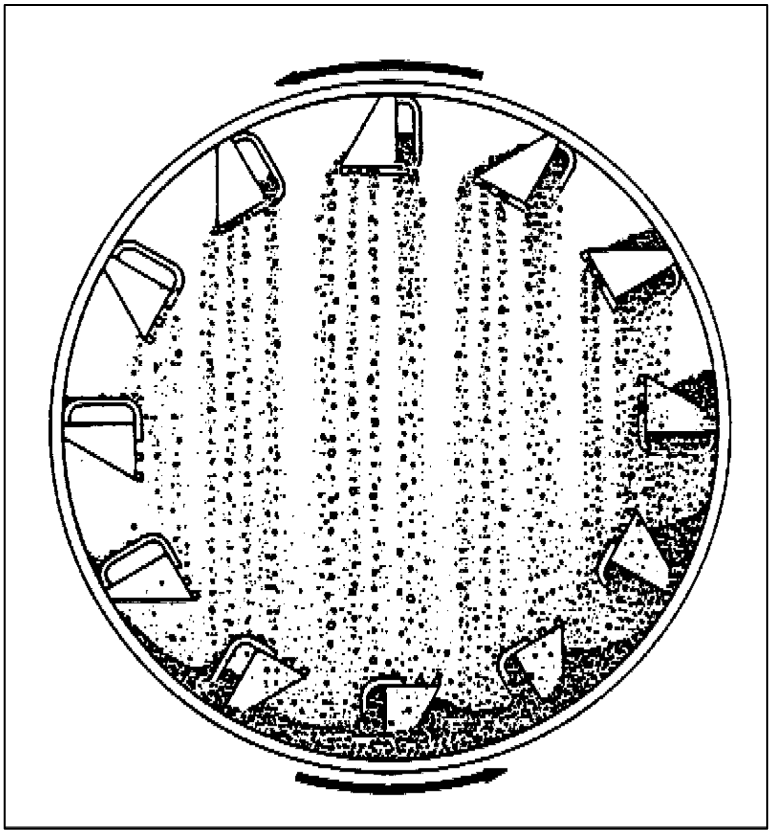
The primary point to watch for in the cold aggregate elevator (or conveyor belt on some plants) is that material is not being spilled or lost due to overloading or worn equipment.

Aggregate Drying and Heating

The drying and heating of the aggregates is carried out by the dryer, but we will also discuss the dust collector as a related part of this function.

Dryer

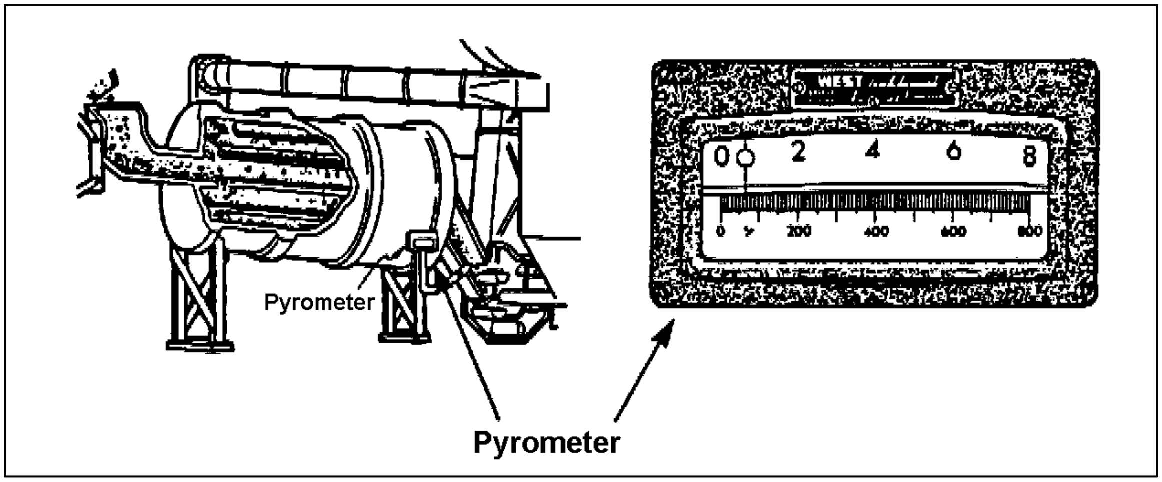
The dryer is a rotating drum with channeled flights that carry the aggregates around and distribute them through the flame of the burner.



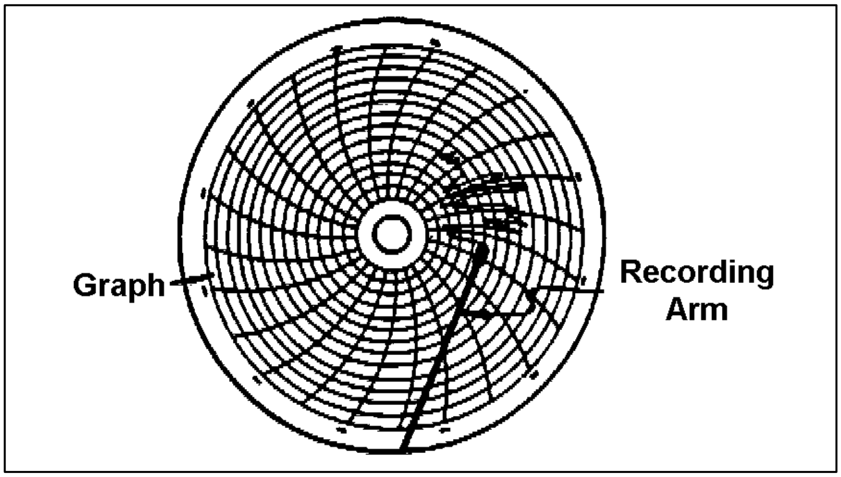
Although you cannot see this process inside the dryer while it is in operation, there are several aspects of dryer operation that you can monitor from the outside and need to be inspected including:

- the temperature of the aggregate as it is discharged,
- the moisture content of the aggregate, and
- the combustion of the burner fuel which may leave an oily residue on the aggregate.

Monitoring the temperature of the aggregate is fairly simple. Most dryers are equipped with an indicating pyrometer for measuring the temperature of the aggregate as it passes through the discharge chute. The proper placement of the pyrometer is an important factor. The pyrometer must be able to record the temperature of the flow of material. The pyrometer is a slow reacting device. Caution should be exercised when adjusting the temperatures.



In the operator’s control station, all plants also have a recording pyrometer that provides a continuous record of the temperature on a circular graph as shown below, or any other continuous graph or plot.



Although there is no gauge to show the moisture content of the aggregate, you can generally tell whether or not the aggregates are dry enough by watching for:

- sweating on the walls of the hot bins (except at the start of the day’s operation when sweating is normal), or
- excessive steam rising from the hot mix.

If the aggregates are not hot enough or dry enough, adjustments can be made by:

- adjusting the slope of the drum,
- reducing the cold feed rate so that less aggregate is in the drum at one time, or
- adjusting the burner to increase the temperature of the flame.

As a general rule, it is better to reduce the cold feed rate or **adjust drying time** rather than to increase the burner's temperature because other problems can arise from excessive temperatures.

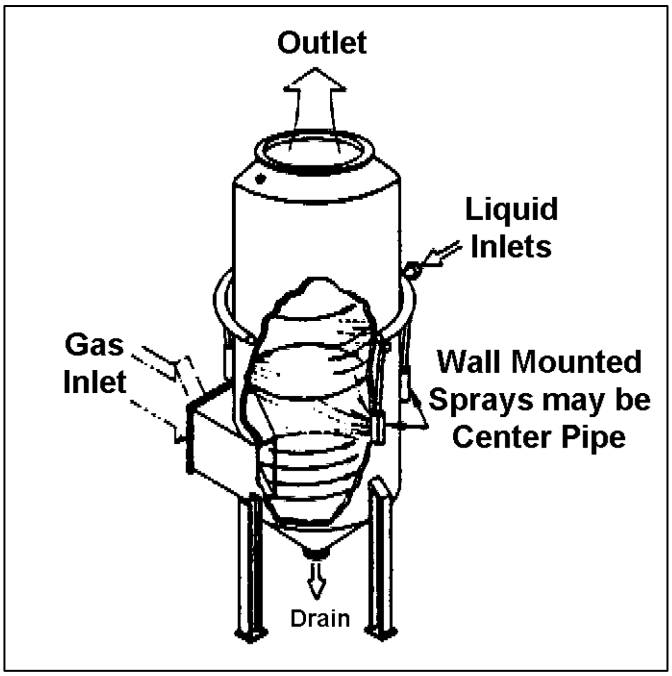
Incomplete combustion of the burner's fuel can leave a black, oily residue on the aggregates which hinders their coating with asphalt. Indications of this problem are:

- black smoke from the exhaust stack of the dust collector, and
- a visual check or sampling of the aggregates before they are mixed with the asphalt.

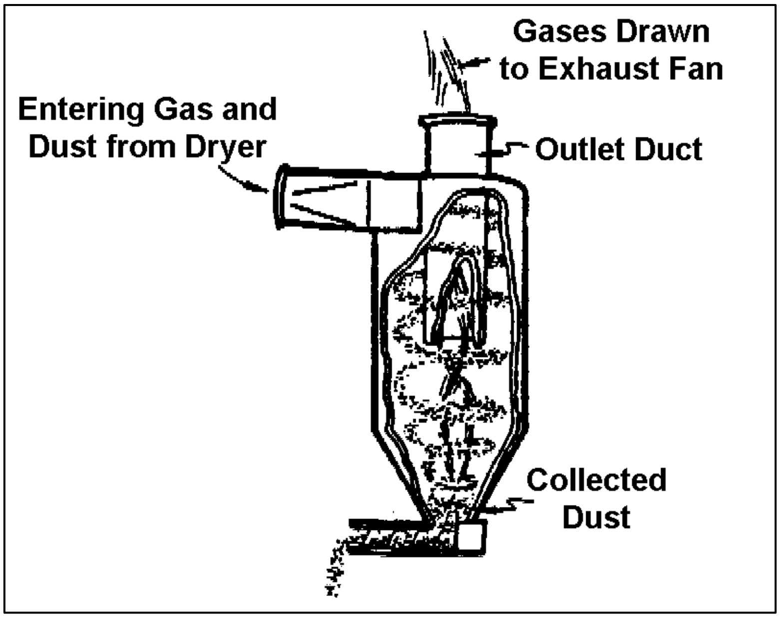
Dust Collectors

There are several different types of dust collectors that might be used including:

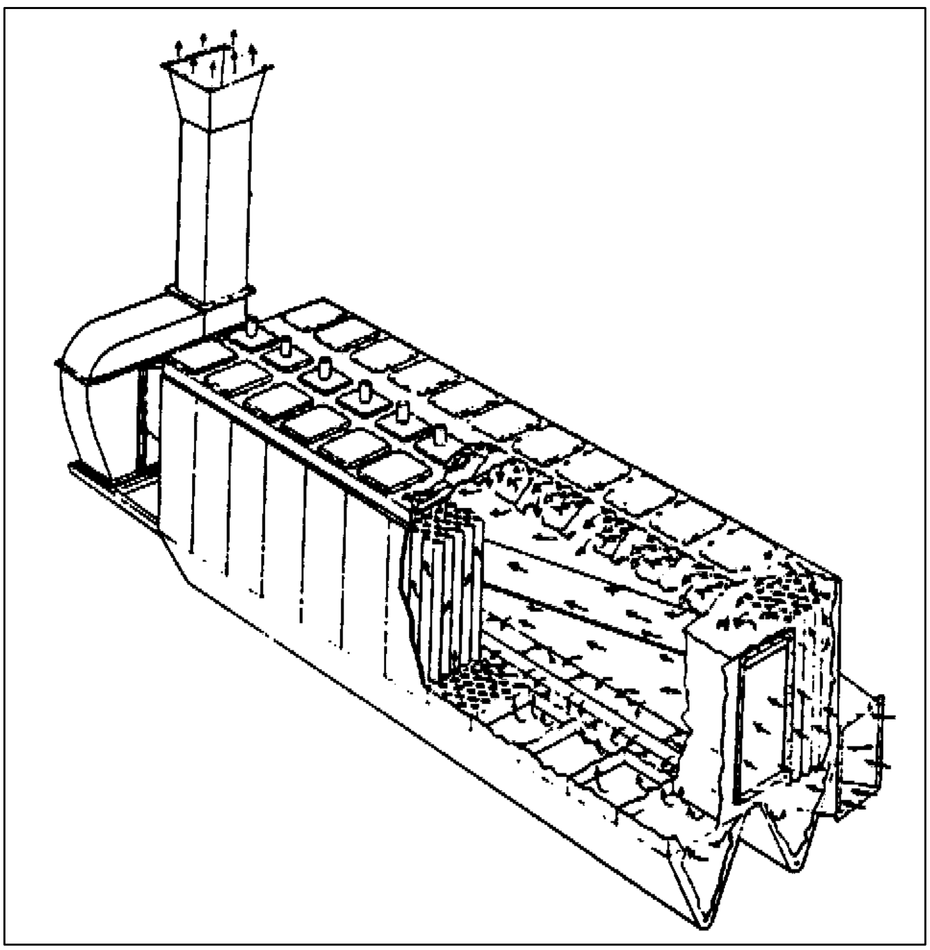
- wet collectors that spray water into the gases to remove the fines in a wet sludge,



- dry centrifugal collectors which whirl the gases around until the dust settles at the bottom and is removed by an auger, and



- dry bag-house collectors in which the gases and dust are forced through a series of cloth bags which filter out the fines.



Regardless of the type of dust collector used, your primary concerns as an inspector are to:

- see that the collected fines are not returned to the hot aggregates, except when specifically authorized by the Project Engineer as covered by contract requirements,
- observe the dust collector's exhaust stack for indications of problems in the dust collector or dryer.

Hot Aggregate Screening and Storage

From the dryer, the heated aggregates are carried up the hot elevator to the gradation screens which re-separate them into the hot bins.

Gradation Screens

You may encounter a variety of configurations of the gradation screens but generally they are set up to separate the aggregates into four different aggregate sizes as shown below on the left, or three aggregate sizes as diagrammed on the right.

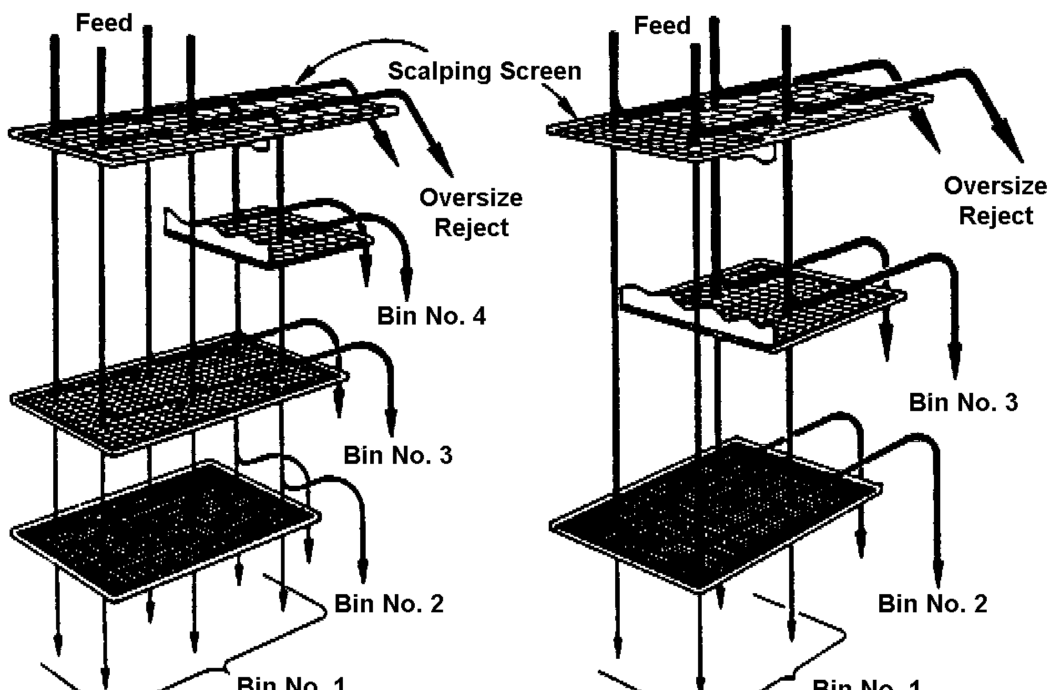


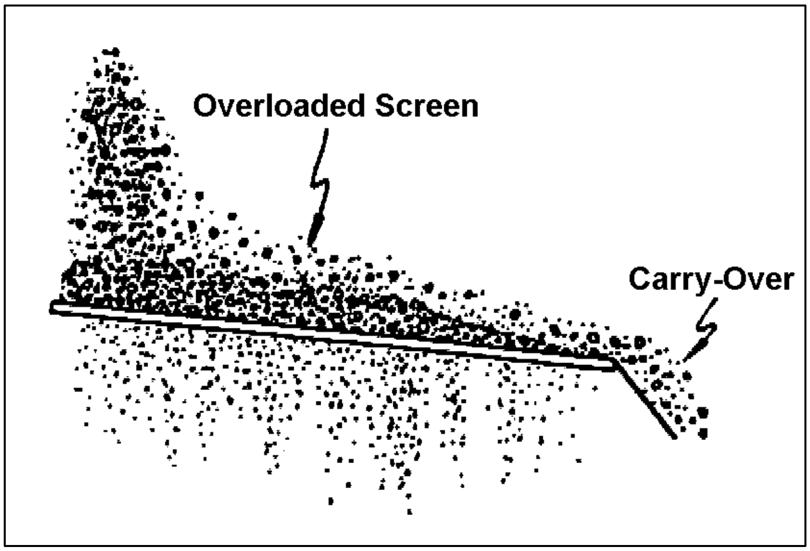
Figure 1 Arrangement for 4 Aggregate Sizes

Figure 2 Arrangement for 3 Aggregate Sizes

Regardless of the number of sizes of material or the arrangement of the screens, they:

- are equipped with a motor that tilts or vibrates the screens to keep the aggregate moving over the screens;
- are set up so that oversized material is rejected through a "scalping" chute; and
- should have sufficient capacity that:
  - ➢ is greater than the drying rate so it will not become overloaded, and
  - ➢ can keep up with the batching and mixing rate.

If these basic requirements are not met, the screens can tend to overload causing "carry-over" of finer material that should have passed through the screen but ends up in a bin with coarser aggregates.

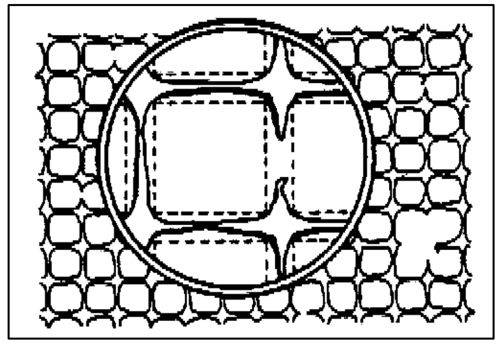


Some slight carry-over may be allowable depending on the gradation tolerances of the mix design. But fluctuating or excessive amounts of carryover can result in a mix that is not uniform or does not meet the requirements of the mix design.

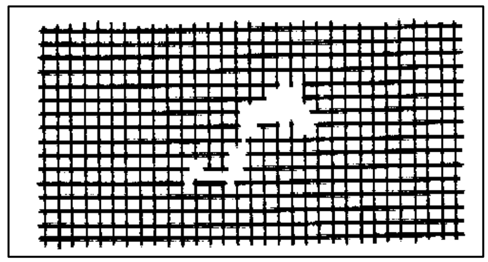
In order to minimize overloading, clogging, and the resulting carry-over, the contractor should have the screens checked and cleaned periodically. Whenever the screens are opened for cleaning you should inspect them:

- to see that they are adequately cleaned to remove particles that are clogging screen openings,

- for worn screens that may allow many slightly larger particles to pass through and need to be replaced,



- for broken screens that allow some much larger particles to pass through and must be repaired or replaced, and



- to see that the vibrator is operating properly.

Other indications of screening deficiencies that you must watch for are:

- smaller particles carrying-over with the oversized through the overflow chute,
- visual indications of smaller (by carry-over) or larger (by screen wear or breaks) particles in a hot bin, and
- gradation test results as positive evidence.

Inspectors should be aware of the difference between square screens, slotted screens, and the operation they perform.

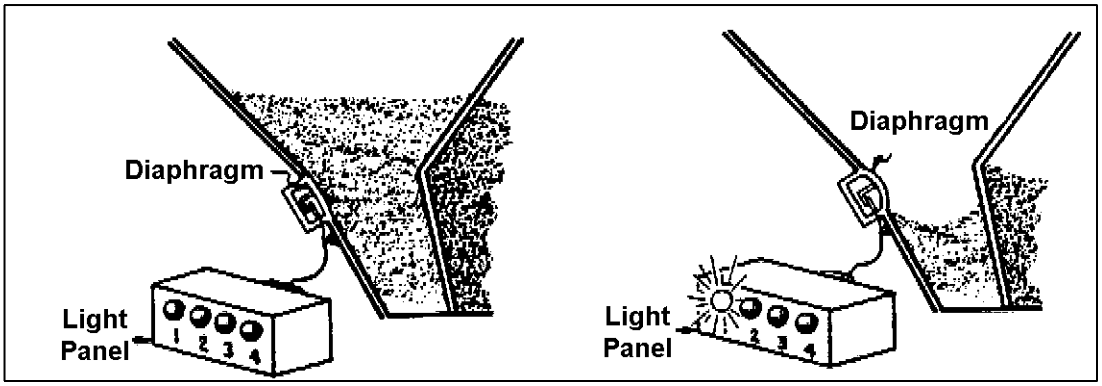
Hot Bins

The hot bins, like the screens, must have sufficient capacity to keep up with the other production rates of the plant. If they are too full, they can overflow or will let the aggregates cool off before they are mixed. So, they must be equipped with:

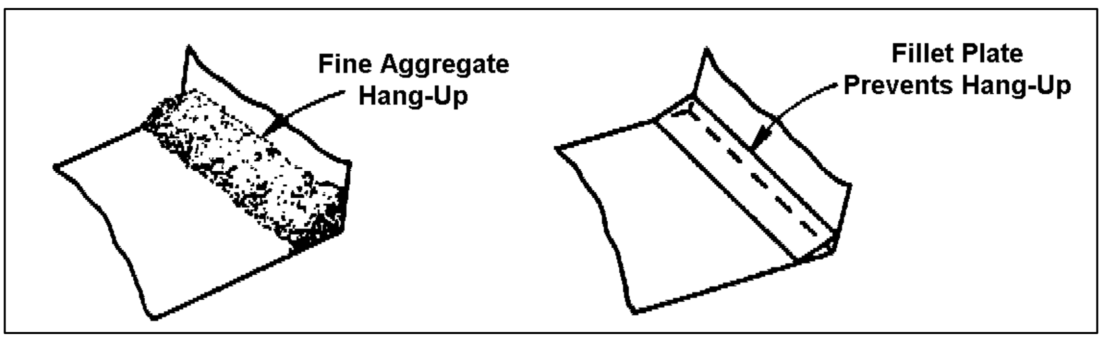
- partitions that are high enough and in good condition (no holes or breaks) to prevent the aggregates from intermingling, and
- overflow chutes to keep the bins from overloading.

Special attention should be paid to the discharge of the aggregates from the hot bins. Some of the key points to watch for are summarized below.

1. Never allow the bins to completely empty. Each hot bin should be equipped with a low-level indicator to warn when the bin is low. The light panel for the type of indicator shown below is usually in the operator's control station. Make sure that the indicator is working properly.



2. Watch for "hang-up" of fines in the corners of their hot bin. When fines hang up, they initially fail to discharge and then break free all at once causing inaccurate proportions in the batching. Hang-ups can be minimized by welding fillet plates in the sharp corners of the fines bin.



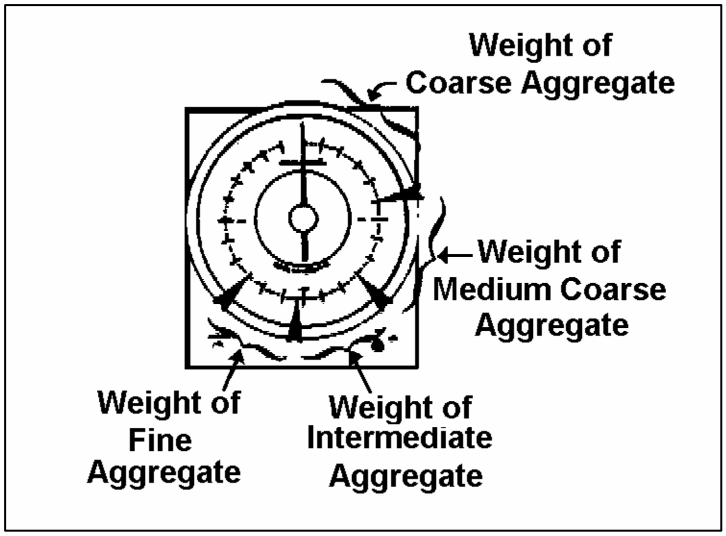
3. The discharge gates must be able to open and close quickly with no leaks when they are closed. Slow-closing or leaking gates will let more aggregates fall into the weigh box than the amount specified.

   Note: To check a leaking bin – the operator can pull 300± lbs. into the weigh hopper and monitor the scales to verify that they do not increase.

Weighing Aggregates and Admixture

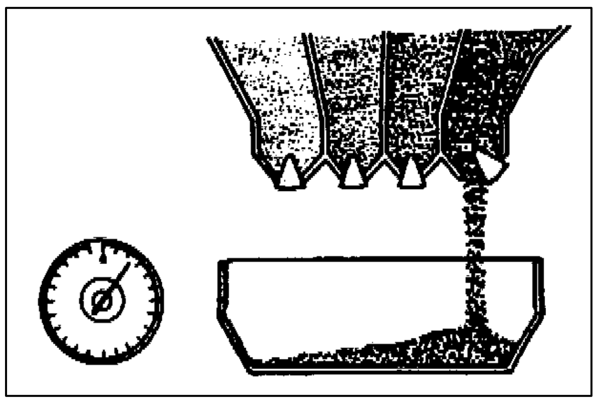
Weighing Aggregates

Aggregates are measured in turn following a definite sequence from coarse to fine. Most batch plants use an automatic cut-off system based on the accumulated weights of the aggregates in the weigh box.

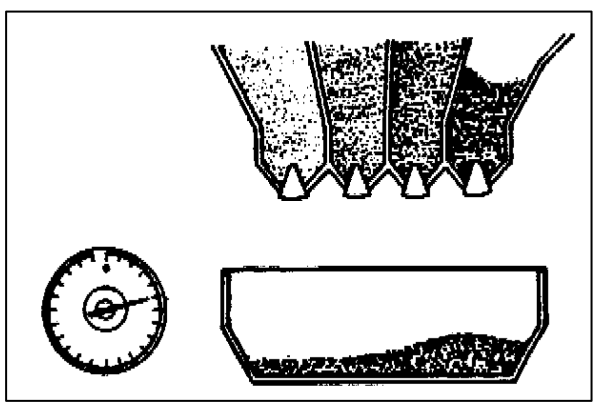


The basic weighing sequence is summarized below.

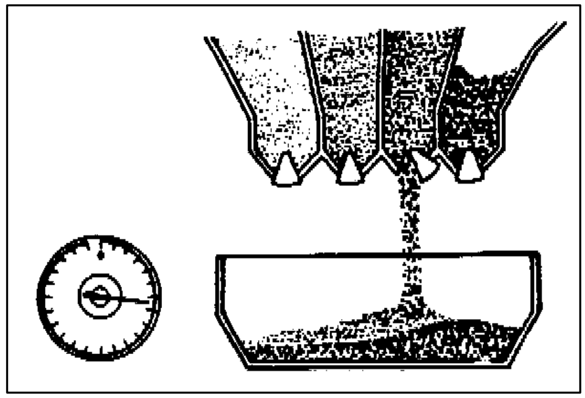
1. The gate of the coarsest hot bin opens to discharge the aggregates into the weigh box.



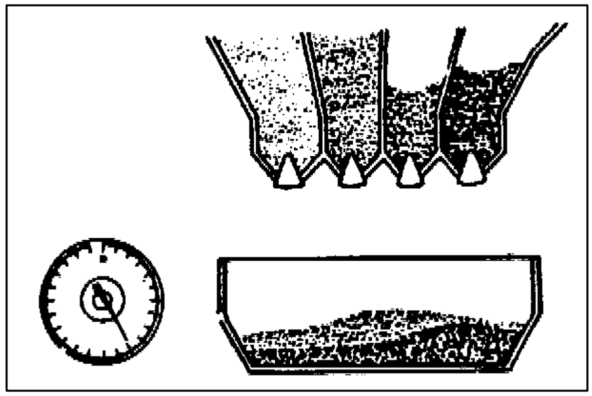
2. When the scale reading reaches the first pre-set weight the gate is closed.



3. The gate for the next bin is opened to discharge its aggregate into the weigh box.



4. When the second pre-set cumulative weight is reached, the second gate is closed.



5. This basic process is repeated for each of the remaining bins until the total batch weight is reached.

There are two primary reasons why the coarse aggregates are weighed first:

1. Fines on top of coarser material will settle down into the coarser material so that more of the voids are filled and the total batch can more easily “fit” into the weigh box.
2. If fines are in the bottom of the weigh box, they will also be in the bottom of the pugmill where they tend to stick to the sides and bottom just out of reach of the pugmill’s mixing paddle arms.

To determine the cumulative weights to be pre-set on the scale:

1. Determine the percentage needed for each hot bin from the mix design.
2. To determine the weight needed from each bin, multiply each percentage times the total weight to be batched.
3. Add the weights in sequence from coarse to fine to determine the cumulative pre-set weights.

For example, let’s assume that the desired batch size is 4,000 pounds and the mix design indicates an asphalt content of 5 percent and the following percentages from each aggregate bin:

- Bin No.4 (Coarse) 13%
- Bin No.3 (Medium Coarse) 32%
- Bin No.2 (Intermediate) 20%
- Bin No.1 (Fines) 35%

The total aggregate weight is calculated by 4,000 lbs. – (0.05 x 4,000) = 3,800 lbs.

Then the weights from each bin are calculated as follows:

Bin No. 4:	13% x 3,800 lbs. =	494 lbs.
Bin No. 3:	32% x 3,800 lbs. =	1,216 lbs.
Bin No. 2:	20% x 3,800 lbs. =	760 lbs.
Bin No. 1:	35% x 3,800 lbs. =	1,330 lbs.

And the cumulative weights are calculated like this:

1st Setting	(Bin No. 4)	494 lbs.		
2nd Setting	(Bin No. 3 & 4)	1,216 lbs.	+ 494 lbs.	= 1,710 lbs.
3rd Setting	(Bin No. 2, 3 & 4)	760 lbs.	+ 1,710 lbs.	= 2,470 lbs.
4th Setting	(Bin No. 1, 2,3 & 4)	1,330 lbs.	+ 2,470 lbs.	= 3,800 lbs.

Weighing Mineral Admixture

If mineral admixture is used, it needs some special consideration in terms of:

- when it is weighed in the aggregate weighing sequence, and
- how its proportioning is calculated.

As a general rule, the mineral admixture should be weighed in the middle of the sequence, between the coarse and fine aggregates. This helps to keep the very fine mineral admixture from:

- clinging to the bottom of the pugmill if weighed first (as with fine aggregates), or
- being blown away by the wind if it is weighed last.

If mineral admixture, by weight of the mineral aggregate, is added to the proportioning example previously discussed, the bin percentages from the mix design would be as shown below:

Bin No. 4	13%	
Bin No. 3	32%	100% Aggregate
Bin No. 2	20%	
Bin No. 1	35%	
Mineral Admixture	2%	
	102%	= (100% + % Admixture)

For a 4,000 pound batch at a 5% asphalt content and 2% mineral admixture, and using the same bin percentages of the previous example; the individual bin weights and cumulative weights would be calculated as follows:

Weight of Asphalt = 0.05 x 4000 = 200 lbs.

Weight of Aggregate and Mineral Admixture = 4000 - 200 = 3800 lbs.

Weight of Aggregate = 3800 x $\frac{100}{102}$ = 3725 lbs.

Bin No.					**Individual Weights**				**Cumulative Weights**
4	13%	x	3725 lbs.	=	484 lbs.	+		=	484 lbs.
3	32%	x	3725 lbs.	=	1192 lbs.	+	484 lbs.	=	1676 lbs.
Mineral Admixture	2%	x	3725 lbs.	=	75 lbs.	+	1676 lbs.	=	1751 lbs.
2	20%	x	3725 lbs.	=	745 lbs.	+	1751 lbs.	=	2496 lbs.
1	35%	x	3725 lbs.	=	1304 lbs.	+	2496 lbs.	=	3800 lbs.

One more important aspect of weighing aggregates and mineral admixture is that the weight box scale mechanism should be checked for its:

- certification,
- cleanliness (spilled aggregates can jam the scale),
- general condition, and
- accuracy using check weights and by zeroing.

Hot Bin Gradation Acceptance

When gradation testing for acceptance is performed by ADOT personnel on samples of aggregate for each hot bin of a batch plant operation, the contractor is required to provide a sampling device and access to obtain these hot bin samples. For details on the sampling device and sampling method, see **Field Sampling and Testing for Bituminous Construction** (Course 301). The gradation for each hot bin should first be determined according to Arizona Test Method 201, the resulting hot bin gradations shall then be mathematically composited using the percentage by weight of each hot bin actually utilized in the final mix. This gives a calculated gradation for the aggregate mixture prior to the addition of asphalt cement.

The percentage by weight of each hot bin actually utilized is determined from the dial settings in the hot plant for the weigh box, or from the weigh tickets for the weigh box. This is a cumulative weighing process as described in the previous two sections on "Weighing Aggregates" and "Weighing Mineral Admixture." This is done while the plant is in actual operation producing asphaltic concrete mix for laydown on the project. The weight of material from each bin added to the weigh box can be calculated and divided by the total weight of aggregate to give the percentage of that bin utilized in the mix.

Sampling of the hot bins and the calculation of the aggregate composite gradation is as required by the Sampling Guide and the applicable specifications. The calculated gradation must be within specified tolerances of the mix design gradation based on results of one test, and also on an average of 3 consecutive tests. Anytime the gradation does not fall within the limits specified, the production of asphaltic concrete should cease and the contractor must recalibrate or adjust his plant so that tests indicate the gradation is within the tolerance limits specified, before asphaltic concrete mix production may resume.

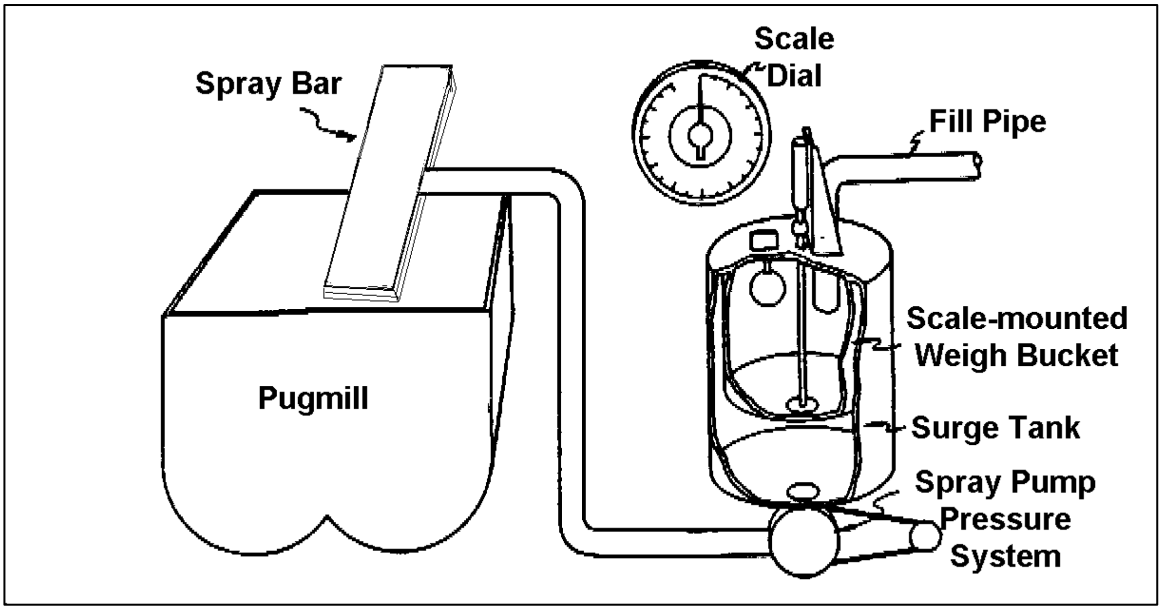
Heating and Weighing Asphalt Cement

Your primary concerns in inspecting the flow of the asphalt cement are its:

- temperature, and
- weight (or volume).

The asphalt cement is heated in its storage tank as previously discussed; you must monitor its temperature to see that it meets the contract specifications and cautions.

The weigh bucket for the asphalt and its feed system are diagrammed below.



The asphalt is pumped from the tank into the weigh bucket. When the asphalt reaches the pre-determined weight, a valve is closed to prevent more asphalt from being discharged into the bucket. Then, at the beginning of the wet-mixing period, another valve at the bottom of the bucket opens to allow the asphalt to be pumped through a spray bar into the pugmill.

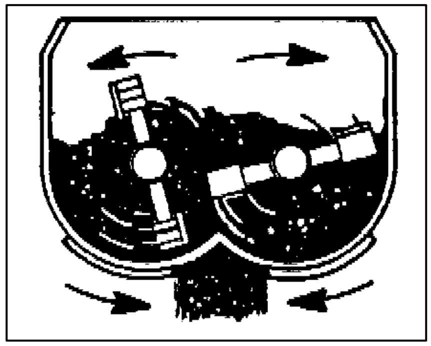
To determine the weight of the asphalt cement needed, you first must determine the total weight of the batch from the manufacturer's weighted capacity and the specified percentage of asphalt.

For example, if the mix design calls for 5 percent of the **total** mix to be asphalt cement for a 4,000-pound batch weight, the weight of the asphalt cement is determined by multiplying the percent of asphalt times the total batch weight:

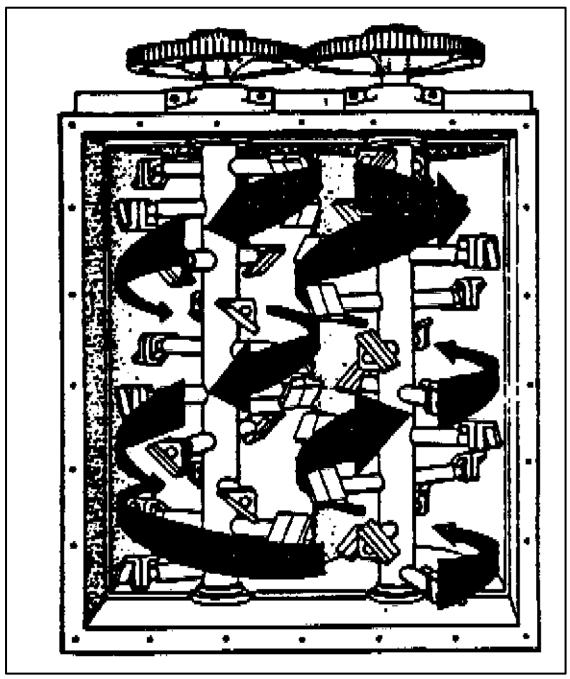
0.05 x 4,000 lbs. = 200 lbs.

Mixing

The pugmill must have twin shafts that rotate in opposite directions so that the top of the rotation moves the material to the sides and the bottom rotation moves it into the center.



The paddle heads are set at an angle to produce a circular, or "run-around" action in the pugmill. This is accomplished by reversing the paddle tips in the two opposite corners of the pugmill so that the mix is always kept out of the corners and pushed back toward the center.



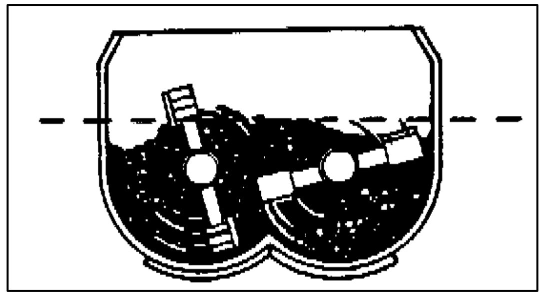
You should check the paddle heads to see that they are:

- properly angled for effective mixing, and
- **not** worn or damaged so that they leave excessive clearance that would allow materials to stick to the sides and bottom unmixed.

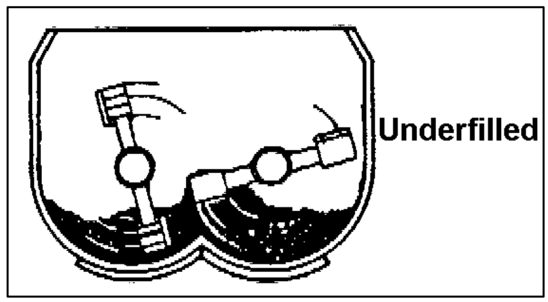
Mixing Level

The level of the materials in the pugmill should be:

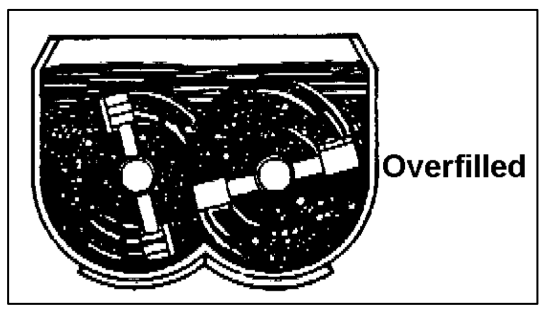
- high enough to cover the two shafts, but
- low enough so that the paddle heads are exposed at the top of their rotation.



If the pugmill is underfilled, the material is just pushed around on the bottom of the pugmill and is not thoroughly blended. (Underfilling can also be a waste of the plant's potential productive capacity.)



If the pugmill is overfilled, the material above the top of the paddles' rotation can remain in that position and not get fully blended with the rest of the material.

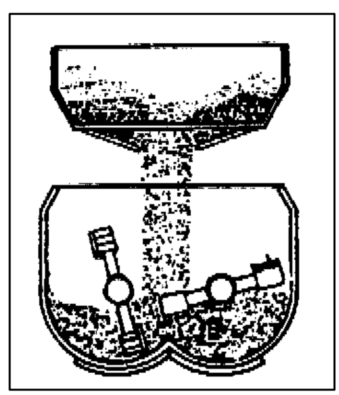


Mixing Cycle

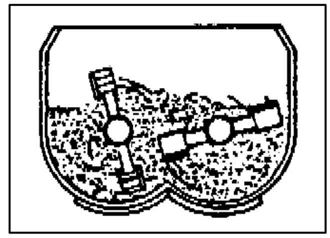
The mixing cycle in a batch plant consists of both dry-mixing and wet-mixing.

Dry mixing is done first as follows:

1. The gates of the weight box are opened and the aggregates and admixture empty into the pugmill.

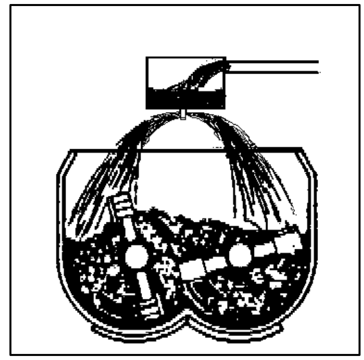


2. The dry ingredients are blended before the asphalt is added.

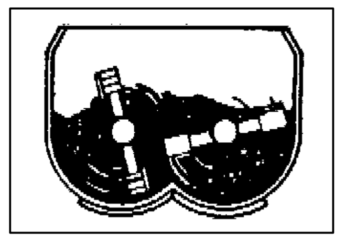


Then, the wet-mixing is done as follows:

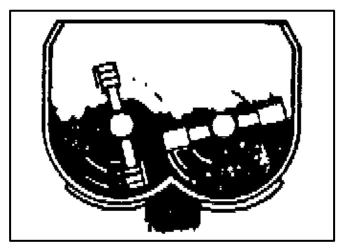
3. The asphalt is discharged into the pugmill by a spray bar.



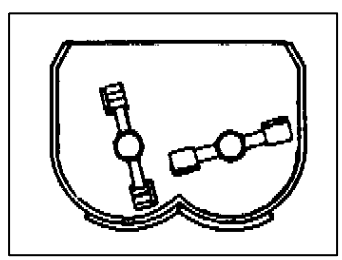
4. The aggregates and the asphalt are mixed.



5. The pugmill gate opens and the finished mix is discharged.



After the mix has been fully discharged, the pugmill gate closes to receive the next batch.



The wet-mixing time is generally the more critical of the two since it involves all materials. It is generally about 30 seconds at the start of production, but some adjustment may be needed to achieve the particle coating.

Section Four Quiz

1. "Bridging" of fine aggregates in the cold bins may be caused by ______________ .

2. Three primary aspects of the drying operation that need to be monitored during production are:
   a. ______________________________
   b. ______________________________
   c. ______________________________

3. The basic requirements for the cold feed gates are that they must:
   a. ______________________________
   b. ______________________________
   c. ______________________________

4. Which of the following are indications that there is excessive moisture left in the aggregates after drying? (Circle one or more)
   a. pyrometer reading
   b. sweating on the walls of the hot bins
   c. black smoke from the exhaust stack of the dust collector
   d. excessive steam from the hot mix

5. As a general rule, which of the following adjustments is the best method of getting moist aggregates dryer? (Circle one)
   a. increasing the temperature of the burner's flame
   b. reducing the cold feed rate
   c. using a different type of dust collector

6. The inspector's primary concerns with the dust collector are to:
   a. ______________________________
   b. ______________________________

7. Gradation screens are usually set up to divide the aggregates into ... (Circle one or more)
   a. ... 2 or 3 aggregate sizes.
   b. ... 3 or 4 aggregate sizes.
   c. ... 4 or 5 aggregate sizes.

8. “Carry-over” is caused by ... (Circle one or more)
   a. ... inadequate drying of the aggregates.
   b. .... worn or broken screens.
   c. ... clogged or overloaded screens.
   d. ... hot bin discharge gates that close slowly or leak.

9. Which of the following best summarizes the proper sequence for weighing aggregates? (Circle one)
   a. intermediate first; then coarse; and fines last
   b. intermediate first; then fines; and coarse last
   c. fines first; then intermediate; and coarse last
   d. coarse first, then intermediate; and fines last

10. If mineral admixture is to be included in the mix it is weighed ... (Circle one)
    a. ... first, before any of the aggregates.
    b. ... in the middle, between the coarse and fine.
    c. ... last, after all of the aggregates.

11. The mixing cycle consists of:
    a. ____ , first; and
    b. ____ , last.

12. Determine the individual weights for the aggregates and asphalt cement and the cumulative weights (in sequence) for each hot bin for a 4,000-pound (total weight) batch using the following percentages.

Bin No.	Specified Proportions	Individual Weights	Cumulative Weights
Bin No.3 (Coarse)	22%	____________	____________
Bin No.2 (Intermediate)	36%	____________	____________
Bin No.1 (Fines)	42%	____________	____________
Asphalt Cement	5%	____________	____________

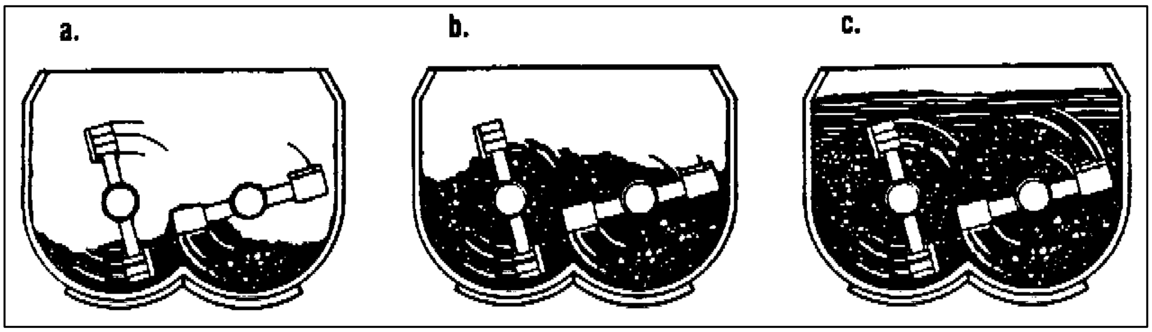
13. The inspector's primary concerns with respect to the asphalt cement are:

    a. ______________________________ , and

    b. ______________________________ .

14. Which of the following diagrams represents the proper level of materials in the pugmill?

    ____



Section Four Quiz Answers

1. excessive moisture

2. a. temperature
   b. moisture content
   c. burner fuel combustion

3. a. are adjustable
   b. have an indicator
   c. have a locking device

4. b. sweating on the walls of the hot bins
   d. excessive steam from the hot mix

5. b. reducing the cold feed rate

6. a. see that the fines are not used in the mix unless authorized by the Engineer and contract specifications;
   b. observe the exhaust stack for indications of problems.

7. b. 3 or 4 aggregate sizes.

8. c. clogged or overloaded screens.

9. d. coarse first; then intermediate; and fines last

10. b. in the middle, between the coarse and fine aggregates.

11. a. dry-mixing
    b. wet-mixing

12.

Bin No.	Specified Proportions	Individual Weights	Cumulative Weights
Bin No.3 (Coarse)	22%	836 lbs.	836 lbs.
Bin No.2 (Intermediate)	36%	1,368 lbs.	2,204 lbs.
Bin No.1 (Fines)	42%	1,596 lbs.	3,800 lbs.
Asphalt Cement	5%	200 lbs.	-----

13. a. its temperature
    b. its weight (or volume)

14. b. (above the shafts and below the top of the paddle arms' rotation)

Notes

Fourth Discussion Period
(Inspecting Drum-Mix Plants)

Section Five: Inspecting Drum-Mix Plants

This section reviews the inspecting of drum-mix plants in terms of their:

- cold aggregate supply,
- asphalt supply and feed,
- mineral admixture supply,
- drying and mixing, and
- hot mix storage

Remember that the key characteristics of the drum-mix plant that distinguish it from a batch plant are that the drum-mix plant:

- operates continuously rather than one batch at a time;
- combines the aggregate heating and drying function with the mixing function in the same drum;
- has no gradation screens, aggregate hot bins, weigh box or weigh bucket;
- has a pugmill as a separate mixer for mixing mineral admixture (if required) with aggregate; and
- cold feed gates and belts must be accurately calibrated.

Cold Aggregate Supply

The cold aggregate supply for a drum-mix plant is generally similar to that of a batch plant. Aggregates are stockpiled in different gradations, transferred or fed to cold bins, and proportionally fed into the rest of the plant.

The key difference is that the cold feed system in a drum-mix plant is the only means of measuring and controlling the aggregates. Because drum-mix plants do not reseparate and remeasure the aggregates later in the process, particular care is needed to ensure that:

- **<u>stockpiles are kept clean, well-graded, fully separated and free of excess moisture;</u>**
- the cold bins are separated and in good condition;
- the proportioning of the aggregates is accurate; and
- a pad of 6-inch thick material should be left in place at all times. This will eliminate the possibility of contamination with underlying soils.

Stockpiling

Inspecting the aggregate stockpiles is basically the same as for batch plants, but they must be strictly controlled – particularly in terms of intermingling of aggregate materials or contamination by foreign material that might be unacceptable in the initial feed of a batch plant.

Cold Bins

The cold bins are generally the same as for batch plants, but they must be strictly controlled. Because an empty cold bin in a drum-mix plant would <u>**force all operations to stop**</u>, each bin should be equipped with a low-level indicator similar to those used on the hot bins in a batch plant. Make sure that the hot plant operator does not override the system manually.

Cold Feed Gates and Belts

The feed gates and belts are similar to those in a batch plant in that they must:

- be adjustable,
- have a graduated indicator, and
- be lockable.

However, the cold feed system for a drum-mix plant has no additional means of proportioning and controlling the flow of the aggregates.

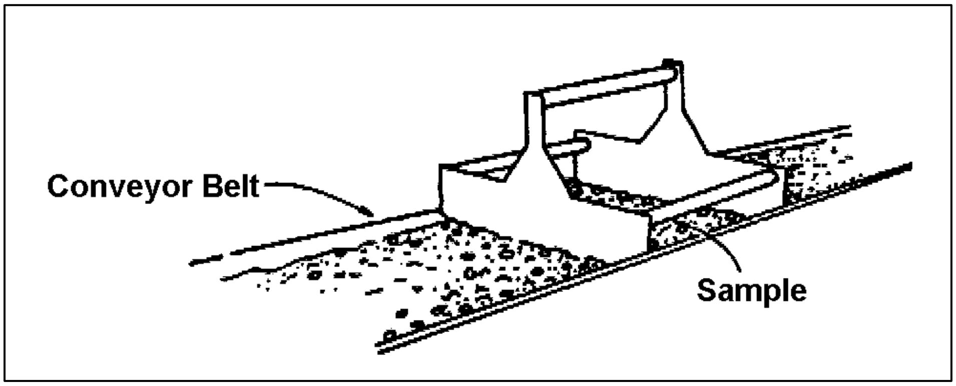
The general condition and operation of the feed system should be checked. Before starting production, each gate and belt must be calibrated so that it proportions the aggregate correctly. This is done using the following steps:[2]

1. Close and lock all gates except the first one to be calibrated.
2. Set the gate and belt at the desired setting.
3. Start the cold feed system and let it run to normal operating speed.

[2] Calibration of the cold feed system is not performed by ADOT personnel because the contractor is responsible for controlling gradation on cold feed or end product acceptance. However, the contractor should perform the procedures as part of his quality control, and is required to provide calibration documentation for ACFC 407, AR-AC 413, recycled AC 408, and AR-ACFC 414. As a result, ADOT inspectors should become familiar with calibration procedures.

4. Stop the system, take a sample from the belt with a template as shown below, and weigh the sample. For additional details on this sampling method, see **Field Sampling and Testing for Bituminous Construction** (Course 301).

   Note: The contractor should be responsible for taking the cold feed sample which shall be witnessed by the inspector.



5. Repeat steps 1 through 4 for each of the other bins.
6. Calculate the percentage of the total amount sampled for each bin.[3]
7. Compare these percentages with those specified in the mix design.
8. Make any gate and belt adjustments that may be needed to comply with the mix design.

For example, let's assume a sample is obtained for Bin No. 1 and it weighs **3.2 lbs.** Then Bin No. 2 is sampled and that sample weighs **5.6 lbs.** The same process is repeated for the final bin, Bin No. 3, and that sample weighs **7.2 lbs.**

The total weight of all the samples is determined as follows:

3.2 lbs. + 5.6 lbs. + 7.2 lbs. = 16.0 lbs. total weight

Then the percentage for each sample is calculated, based on the total weight of the samples:

Bin No. 1: $\frac{3.2 \text{ lbs.}}{16.0 \text{ lbs.}} = 0.20$ or 20%

Bin No. 2: $\frac{5.6 \text{ lbs.}}{16.0 \text{ lbs.}} = 0.35$ or 35%

Bin No. 3: $\frac{7.2 \text{ lbs.}}{16.0 \text{ lbs.}} = 0.45$ or 45%

[3] If there are significant differences in the moisture content of the different gradations, it may be necessary to allow for moisture content in calculating the percentages.

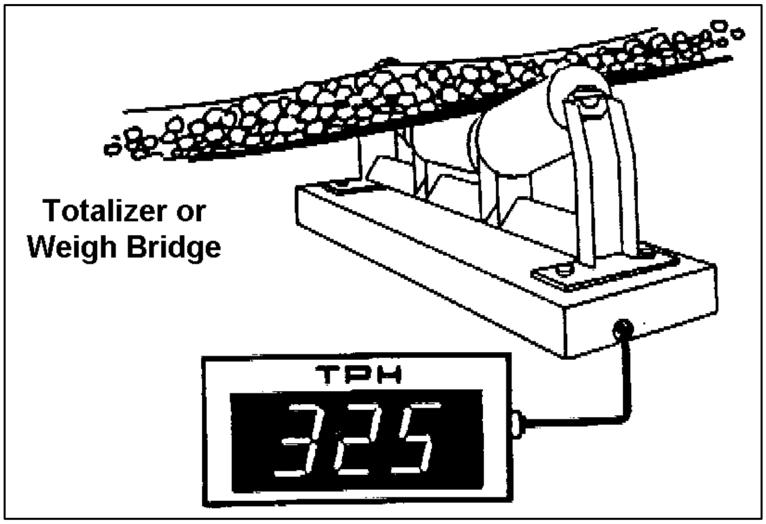
If these percentages are not in compliance with the mix design, then further gate and belt adjustments would be made until the mix design requirements are satisfied.

Even after production begins, the feed gates and belts should be checked each day by the contractor as part of his quality control to see that they are still:

- adjusted and locked at the proper setting, and
- operating properly with a uniform flow of material.

Cold Feed Control

The cold feed bins at a drum-mix plant are equipped with variable speed motors to drive the individual feed belts under the bins. These belt feeds are continuously shown on the master feed control in the operator's control station so that the operator can monitor and adjust the flow of material without stopping production and readjusting the individual bin gates.



The flow of the aggregates is also monitored and controlled by means of a totalizer or weigh bridge under the master feed control. It measures the weight of all the aggregates as they pass along the conveyor in tons per hour. On most drum-mix plants, the totalizer is linked to the asphalt cement flow so that a change in the aggregate flow will automatically adjust the asphalt cement rate proportionately.

The total tons per hour shown on the totalizer depends primarily on the capacity of the plant. This production rate and the mix design can be used to calibrate the cold feed system at the start of production using the following steps:

1. Determine the percentage needed from each bin from the mix design.
2. Set each bin's cold feed system by adjusting:
    - the gate opening, and
    - the belt speed;
3. Check the flow from each bin by:
    - determining the pounds of aggregate being fed for each belt revolution, and
    - converting the pounds per revolution into tons per hour, and
    - calculating the percentage of the total tons per hour;

4. Adjust the cold feed system as needed so that the percentage from each bin will produce a mix that complies with the mix design.
5. Document well all calibration for belt scales.

Cold Feed Gradation Acceptance

When gradation testing for acceptance is performed by ADOT personnel on the total cold feed of a drum-mix asphalt plant, the contractor is required to provide an approved sampling device to sample the cold feed on a moving conveyor belt or the conveyor belt must be stopped and the sample must be obtained using a template shaped to the contour of the belt. For additional details on these sampling methods, **Field Sampling and Testing for Bituminous Construction** (Course 301).

This sampling of the cold feed is as required in the Sampling Guide and applicable specifications. The cold feed gradation must be within specified tolerances of the mix design gradation on each of these mix types based on the results of one test, and also the average of 3 consecutive tests. Anytime the gradation does not fall within the limits specified, the production of AC should cease and the contractor is required to recalibrate or adjust his plant so that tests indicate the gradation is within the tolerance limits specified before AC mix production may resume.

Asphalt Supply and Feed

The asphalt cement storage tank has the same basic requirements as the storage tank in a batch plant:

- a heating device,
- a means of monitoring the temperature, and
- insulation to maintain the heat.

The primary difference is that the asphalt cement is pumped and measured continuously at a tons-per-hour or gallons-per-hour rate. As previously mentioned, most drum-mix plants have inter-locking measurement systems that:

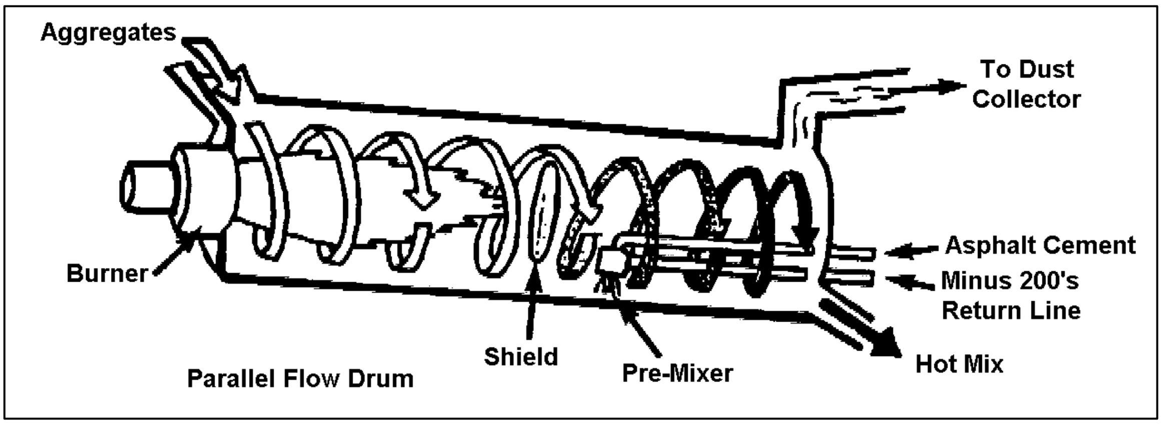
- provide a continuous reading of the quantity of asphalt being entered, and
- automatically adjust the asphalt flow as the total aggregate flow is increased or decreased.

Mineral Admixture Supply and Entry

Mineral admixture must be stored in an enclosed dry silo or bin. It shall be weighed and fed to a pugmill. Mineral admixture must be pre-mixed with the aggregates in the pugmill prior to entering the drum-mixer for mixing with the asphalt cement.

Drying and Mixing

The key to the operations of a drum-mix plant is the combination of the aggregate-drying and mixing functions in one drum.



Aggregate Drying

The drying – or "charging" – end of the drum is very similar to the dryer in a batch plant. The aggregate is rotated around and distributed through the flame of a burner so that it is heated and dried. The key difference is that the drum-mixer leaves some moisture in the aggregates to help retain fines and assist in the mixing process.

Mixing

In the mixing – or "discharge" – end of the drum, the aggregates are sprayed with asphalt as they are rotated and distributed through the drum.

The asphalt cement usually is sprayed on to the aggregates about ten to twelve feet in from the hot mix discharge chute so that the aggregates will be fully mixed and coated by the time they leave the drum. The asphalt spray is adjustable to different distances into the drum.

However, one key consideration that must be given is where the asphalt is added in its relationship to the burner flame. It must be "shielded" from the flame so that it does not come in direct contact with the flame that could burn it.

The “shielding” may be done in a variety of ways including:

- arranging the flights in such a manner that a dense veil of aggregate is formed between the flame and the asphalt,
- positioning the burner further back, or
- providing a shielding device near the middle of the drum.

Although you cannot monitor the temperature of the uncoated aggregates in the drying end of the drum, you must closely monitor the temperature of the mix as it is discharged at the other end.

Drum-Mixer Adjustments

One of the key adjustments on a drum-mixer is the position of the asphalt spray. Typically, some experimentation is needed before production to position the asphalt spray so that it provides full coating of the aggregates without getting too close to the burner flame.

The total retention time (drying and mixing) in the drum-mixer can be adjusted by changing the angle of the drum. This is generally done as a pre-production adjustment because changes during production usually require repositioning other elements of the plant. If adjustments are needed during production, it is usually more practical to adjust:[4]

- the burner flame, or
- the flow rates of the aggregates and asphalt.

Dust Collection

The dust collector for a drum-mix plant is basically the same as for batch plant. It may be any or a combination of various types, but it still carries out the same function of filtering out the fines to minimize air pollution.

Hot Mix Storage

From the discharge chute of the drum-mixer, the hot mix is carried by a hot elevator or conveyor belt to the storage silo or hopper. The inside of the storage silo should be insulated to retain the heat and designed to minimize segregation of the mix. Some hot mix storage silos have a weigh hopper at the bottom to measure out each truckload as it is discharged.

Different contractors have different means to minimize the segregation. The inspector should identify which method the contractor is utilizing and make sure the device is working.

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[4] It is recommended that the hot plant inspector review the hot plant diagrams and became familiar with the plant operation.

Section Five Quiz

1. In the cold aggregate supply system, particular care is needed in controlling ... (Circle one or more)
   a. ... the stockpiles.
   b. ... the cold bins.
   c. ... the proportioning of the aggregates.
   d. all of the above.

2. Which of the following aspects of hot bins in a batch plant would also apply to the cold bins of a drum-mix plant? (Circle one or more)
   a. They tend to “sweat” at the start of each day’s production.
   b. They have low-level indicators to warn against emptying.
   c. They open and close separately to measure out each gradation in turn.
   d. None of the above.

3. If mineral admixture is added to the mix in a drum-mix plant, it may be added ... (Circle one or more)
   a. ... directly to the drum by itself.
   b. ... to the aggregates before they enter the drum.
   c. ... to the asphalt cement before it mixes with the aggregate.
   d. ... to the mix after it is discharged from the drum.

4. On drum-mix plants, if the rate of aggregate flow is increased, the asphalt flow rate will ... (Circle one)
   a. ... remain the same.
   b. ... be automatically decreased.
   c. ... be automatically increased.
   d. ... be manually increased or decreased depending on the temperature of the mix.

5. The two primary considerations in determining where the asphalt spray is positioned in the drum are:
   a. ____ , and
   b. ____ .

6. Which of the following drum-mixer adjustments would be more practical after production has started? (Circle one or more)
   a. adjusting the burner flame
   b. changing the angle of the drum
   c. adjusting the aggregate and asphalt flow rates
   d. any of the above

7. In calibrating the cold feed gates, the sample weights for each of four bins are shown below. Determine the percentage of aggregates from each bin.

Bin	**Sample Weight**	**Percentage of Aggregates from Each Bin**
Bin No. 1	3.2 lbs.	____________
Bin No. 2	4.9 lbs.	____________
Bin No. 3	6.8 lbs.	____________
Bin No. 4	7.9 lbs.	____________

Section Five Quiz Answers

1. d. all of the above.

2. b. They have low-level indicators to warn against emptying.

3. b. to the aggregates before they enter the drum.
   c. to the asphalt cement before it enters the drum.

4. c. be automatically increased.

5. a. full coating of the aggregates, and
   b. avoid contact with the burner flame.

6. a. adjusting the burner flame
   c. adjusting the aggregate and asphalt flow rates

7. Bin No. 1 = 14%
   Bin No. 2 = 21%
   Bin No. 3 = 30%
   Bin No. 4 = 35%

Notes

Fifth Discussion Period
(Mix Control and Plant Records)

Section Six: Mix Control

This section reviews mix control in terms of dispatching hot mix from the plant and an overview of the basic requirements for different types of mix.

Dispatching Hot Mix

Regardless of the type of asphaltic concrete plant, the hot mix must be controlled in terms of:

- the haul trucks used and how they are loaded,
- checking the temperature of the mix and collecting samples, and
- determining the weight of the mix in each truck.

Transport Requirements

The basic requirements for trucks used to haul hot mix are as follows:

- The bed of the truck must be tight with no holes or gaps (except a temperature check hole).
- The bed of the truck must be clean and free of any foreign material, cold mix, or fuel oil.
- End-dump trucks must be equipped with tailgate chains to control the discharge of the mix.
- In case of long hauls or bad weather, trucks should be equipped with cover tarps to help retain the heat of the mix.

Although haul trucks must be clean, it is usually necessary to lubricate the bed of the truck so that the mix will discharge smoothly without sticking. An approved asphalt release agent should be used to lubricate the bed. Never allow the contractor to lubricate the bed with fuel oil or any other material that can act as a solvent on the mix. If there is any doubt, a list of approved materials is available from the Arizona Transportation Research Center (ATRC) on the ADOT Intranet, or on the internet at:

http://www.dot.state.az.us/about/atrc/apl.htm.

Haul trucks should be loaded in a manner that will minimize segregation of the mix. To keep segregation to a minimum in the loading process:

- the pugmill or hot mix storage silo should be positioned so that the mix falls into the truck bed from as short a height as possible,
- the discharge into the truck should be as rapid as possible,

- the loading sequence should be as follows:
    - place the first load near front of the truck bed,
    - place the second load near the rear of the truck bed, and
    - place the remaining loads in the center of the truck bed.

Temperature Checks and Samples

The temperature of the mix should be checked after it is loaded into the truck. Temperature checks should be made:

- for the first few loads of each day's production, and
- from random truckloads throughout the day.

Samples of Asphaltic Concrete Friction Course and AR-ACFC (414) are taken from trucks at the plant. Samples of AR-AC (413) are taken from trucks at the plant or from the roadway. Samples of other asphaltic concrete are taken from the roadway.

Weighing Hot Mix[5]

Each truckload of bituminous mix must be accurately weighed before it leaves the plant. Weigh scales are provided by the contractor, but the weighing is carried out by either Department personnel or a certified public weighmaster.

Regardless of who does the weighing, the scales must be:

- checked by section tests prior to starting production,
- previously certified by the Weights and Measures Division of the Department of Administration or a registered service agency within one year prior to its use or if moved and reset,
- accompanied by 20 certified test weights of 50 pounds each, and
- periodically checked to ensure their accuracy.

The basic procedure for weighing hot mix on platform scales is:

1. Determine the tare weight of the empty truck at least once a day (see Std. Spec. 109.01). A tare weight record is maintained for all trucks being used and the tare weight of each truck is checked at such other times as the Engineer directs.
2. The loaded truck is weighed.
3. The weight of the mix is determined by subtracting the truck's tare weight from its loaded weight.

[5] Procedures at commercial scales are slightly different. For additional information, see the *Construction Manual.* The Contractor shall comply with all legal load restrictions in the hauling of materials on public roads beyond the limits of the project. A pamphlet of sizes and weights of vehicles and loads upon highways is available from the Motor Vehicle Division, Arizona Department of Transportation.

If a hopper scale (at the bottom of the mix storage silo on a drum-mix plant) is used, it reads the net weight of the mix before it is placed in the truck. Highway truck units should still have a tare weight to avoid overweight trucks.

The scaleman prepares a weigh ticket for each truckload of mix. However, many public weighmasters use scales that print out their own weigh ticket. In these cases, the scaleman does not need to transfer the information to a separate weigh ticket.

The scaleman on either a platform or hopper scale should check the operation of the scales by:

- balancing the scale to zero (no load) frequently during the day;
- periodically performing “section tests” for platform scales including:
  - a “strain load” test to see that the weights from different truck positions on the scales are within 0.2-percent variation of each other; and
  - a “scale accuracy” test using the test weight by themselves on the platform and on a loaded haul truck; and
- periodically testing the hopper scales using the test weight themselves and increasing greater loads in the hopper.

Regardless of how the load is weighed by Department personnel or public weighmaster; by platform scales or hopper scales – the total gross load of each haul truck must be within established legal load limits. The key elements to remember are that:

- single-axle loads are limited to 20,000 lbs. per axle,
- tandem-axle loads are limited to 34,000 lbs. per axle group, and
- the maximum allowable gross load is dependent on the number of axles and the distance between the first and last axle – up to 80,000 lbs.[6]

Basic Mix Requirements

The requirements for bituminous mix can vary widely depending on the type of mix, how it will be used and the specific mix design.

In general terms, bituminous mix is either:

- Asphaltic Concrete (AC) which may be:
  - specified as either ½-inch mix, ¾-inch mix, 1-inch mix, 1-½-inch mix, or base mix, and
  - may be used as either a “leveling” course or “surface” course;
- Asphaltic Concrete Friction Course (ACFC) which is used as a final riding surface;

[6] See http://www.ops.fhwa.dot.gov/freight/regulate/sw/index.htm for information on truck size and weight regulations.

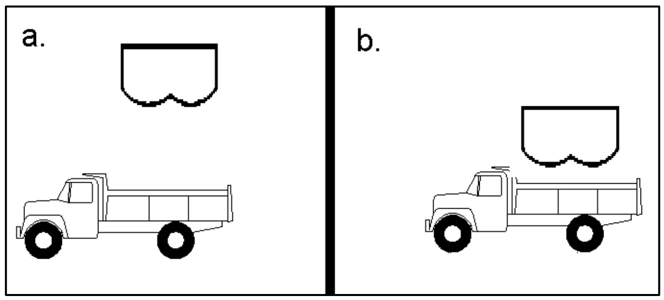
- Recycled Asphaltic Concrete (RAC) which is similar in use to AC but includes salvaged pavement; and
- Asphalt-rubber asphaltic concrete (AR-AC and AR-ACFC) which includes granulated rubber mixed with the asphalt cement prior to mixing with the aggregate.

Section Six Quiz

1. Which of the following materials may be used to lubricate the bed of a haul truck so that the mix will not stick?
   a. clean water
   b. fuel oil
   c. an approved material
   d. none of the above

2. Which of the two diagrams below represents the better position of the truck under the pugmill for loading?

   ____



3. At the plant, when should the temperature of hot mix be checked?

   a. ____

   ____

   and

   b. ____

   ____

4. Which of the following is normally sampled from trucks at the plant?
   a. Asphaltic Concrete, when used as a leveling course.
   b. Asphaltic Concrete, when used as a surface course.
   c. Asphaltic Concrete Friction Course
   d. all of the above

5. The maximum axle load limits are:
   a. ________________________ lbs. for a single axle, and
   b. ________________________ lbs. for a tandem axle.

Section Six Quiz Answers

1. c. an approved material

2. b.

3. a. for the first few loads of each day’s production, and
   b. from random loads throughout the day’s production.

4. c. Asphaltic Concrete Friction Course

5. 20,000
   34,000

Section Seven: Plant Records

This section summarizes the documentation involved in inspecting asphaltic concrete plant operations in terms of:

- measurement as the basis for payment
- key information and events to be documented; and
- the records and reports used.

Measurement for Payment

The key measurements used as the basis for payment for Asphaltic Friction Course, Recycled Asphaltic Concrete and Asphalt-Rubber Concrete, Asphaltic Concrete Asphaltic Concrete are:

- the tons of mix actually used,
- the tons of asphalt cement (excluding wastage), and
- tons of admixture (excluding wastage).

These quantities are based primarily on the weight tickets of the loads of mix as dispatched from the plant and accepted at the roadway and on the delivered quantities of the component materials minus wastage. Depending on the results of in-place testing of the bituminous pavement, pay-factor adjustments may be made as specified in the specifications.

Plant records are used not only to confirm quantities of mix received at the paving site, but also as a means of providing detailed information on the quantities of component materials used in the mix and the conditions under which the mix was produced. Such information is particularly useful when paving problems arise and production adjustments may be needed.

Key Information and Events

Some of the key information and events that need to be documented for plant operations are similar to that of any construction work including:

- routine information – such as the type of work being done, the project, the location, the time of work, and the weather; and

- special events or problems – including any unusual conditions, instructions to the contractor, rejected work or materials, and corrective actions taken by the contractor.

The other key items of information and events that need to be documented specifically for asphaltic concrete plant operations can be grouped into three primary areas:

1. component materials control,
2. mix production, and
3. dispatch of the mix.

The specific documentation needs in each of these areas are summarized below.

Materials Control

The component materials used in the mix must be documented in terms of:

- materials delivered to the plant including the pre-certification documentation and quantities received for asphalt cement, and
- sampling and testing information, including:
  - the time, settings, and sample numbers for all samples collected and witnessed,
  - records of samples sent to the District or other labs for testing, and
  - testing results for tests performed in the field project lab.

Mix Production

For batch plants, the key information and events that need to be documented include:

- the proportions and rates of the aggregate cold feed systems;
- the temperature of the aggregates as they are discharged from the dryer (including a copy of the Recording Pyrometer graph);
- the screen arrangement;
- the batch weighing sequence and proportions of the aggregates and any mineral admixture;
- the quantity and temperature of the asphalt in the storage tank;
- the batch weight of the asphalt cement;
- the durations of the dry and wet batch mixing cycles; and
- quantities of wasted mix and pay-item component materials.

For drum-mix plants, the key documentation needs to include:

- the proportions and rates of the aggregate cold feed system;
- the quantity and temperature of the asphalt cement in the storage tank;
- the type and rate of feed for any mineral admixture;
- the temperature of the mix as it is discharged from the drum-mixer (including a copy of the Recording Pyrometer graph); and
- quantities of wasted mix and pay-item component materials.

Dispatch of the Mix

At either a batch or drum-mix plant, the key documentation needs in relation to dispatching the mix include:

- the truck numbers and tare weights of all trucks being used on the job;
- the truck number, gross weight, load weight, and time of dispatch for each load of mix including:
  - the weight ticket for each truck load, and
  - the weight sheet as a summary of all loads; and
- the time, truck number, and mix temperature for all temperature checks of loaded mix.

Records and Reports

The principle records and reports used in documenting asphaltic concrete plant operations are:

- the Daily Diary,
- delivery tickets and pre-certification documents for materials delivered to the plant,
- the weight tickets and weight sheet,
- a Daily Hot Plant Inspection Report and
- summary reports used in final documentation at the end of the project.

Your instructor should be able to provide copies of examples of most of these records and reports.

Daily Diary

The Daily Diary serves as both a record and a report of all key events that occur during the day. All Daily Diaries are the property of the Department and serve as the foundation of all construction project records, so they must be maintained neatly and legibly in ink They are generally a summary of key events and information, but they must provide sufficient detail so that other personnel can get an accurate picture of what happened each day.

The items recorded in the Daily Diary include:

- such routing information as:
  - identification of the project,
  - the type of work being done,
  - the location of the work,
  - the times work is started and stopped,
  - weather conditions,
  - any important phone calls or other communications sent or received, and

  - an inventory of the contractor’s equipment and personnel resources being used on the work;
- information on any special events or problems encountered such as:
  - any official visitors to the project,
  - unusual conditions that may affect the work,
  - the times and causes of any delays,
  - important discussions with the contractor and any specific instructions or orders given,
  - the rejection of any materials or work including the reasons for the rejection,
  - any changes, adjustments or corrective actions by the contractor, and
  - any other information that may be relevant to any potential disputes or claims;
- summaries of the day’s quantities of:
  - materials delivered to the plant,
  - materials used in mix production,
  - mix dispatched from the plant,
  - wasted mix; and
- key events that occur during the plant’s operation, such as:
  - any adjustments to proportions, feed rates, temperatures, or any other change in plant operations, and
  - any other actions taken by the contractor or ADOT at the plant or roadway that affect plant operations.
- field notes[7] for plant operations, used to record detailed technical information including:
  - basic information on the layout and design of the plant, such as:
    - the types of material feed systems used by the plant,
    - the points of entry for such materials as admixture, or salvaged pavement,
    - the screen arrangement (for a batch plant), and
    - the types of dust collection systems used;
  - specific settings for such elements as:
    - the feed proportions and rates of all materials, and
    - temperature settings; and
  - any calculations made in establishing, changing or confirming operational settings.

Delivery Documents

As asphalt cement or any admixture is delivered, the inspector should check:

- its pre-certification documentation to see that it has been found acceptable as to the type and/or grade specified; and

[7] Because they are a key part of the Department’s permanent record of the work, all field notes must be neat, clear, and accurate.

- its delivery ticket or supplier’s invoice to determine the quantity being added to the plant’s storage systems.

Copies of the pre-certification documentation and delivery tickets should be retained as part of the project records.

Sampling and Testing Documents

The inspector must see that all samples are properly identified with sample tags and all field test results are properly recorded. For additional information on the documentation of specific sampling and testing procedures, see **Field Sampling and Testing for Bituminous Construction** (Course 301).

Weight Tickets and Weight Sheets

Because asphaltic concrete is paid for on the basis of the tons of mix used, the weight ticket for each truckload of mix and the weight sheet summarizing all loads dispatched are two of the most critical documents involved in bituminous mix production. Records of the truck’s tare weights and of scale tests help supplement and verify the accuracy of the weight tickets and the weight sheet.

In order to determine the weight of each load, the scaleman must keep a record of the tare weights of all trucks being used on the project The inspector should see that the scaleman periodically spot-checks the tare weight of each truck to confirm the accuracy of this tare record at least twice a day.

The weight ticket might be on either an ADOT format or on that of a Public Weighmaster, depending on the type of facility being used. It goes with the truck driver and becomes the basis for determining the quantity of material used at the paving site.

The weight sheet summarizes all loads of mix and remains at the plant as a permanent part of the project records. It is often used to recheck and verify the quantities of mix received at the roadway.

The weight sheet form is also used to document section tests and other periodic spot-checks of the scale’s accuracy.

Daily Hot Plant Inspection Report

The Daily Hot Plant Inspection Report provides a relatively detailed summary of the quantities of materials involved in the day's plant operations. Several different formats are currently being used but most of these summarize the quantities of:

- materials in storage at the start of the day,
- asphalt cement and mineral admixture delivered during the day,
- all materials used in production during the day,
- mix dispatched during the day,
- materials in storage at the end of the day, and
- any materials lost or wasted during the day's production.

Some of these daily plant reports also provide information on the plant's operational settings and any adjustments made during the day.

Final Documentation

At the end of the project a final Project Report is prepared by the project Engineer. Plant records provide vital input for this report and the plant inspector may often be needed to assist in compiling the data for the report, particularly in relation to the:

- Summarized quantities and proportions of materials used in producing the mix, and
- Overall performance of the plant's operations.

Appendix
Temperature-Volume Corrections for Asphaltic Materials

Group 0 – Specific Gravity at 60° F Above 0.966

LEGEND: t = observed temperature in degrees Fahrenheit
M = multiplier for correcting asphalt cement volumes to the basis of 60° F

t	M	t	M	t	M	t	M	t	M	t	M	t	M	t	M	t	M	t	M
0	0.0211	50	1.0035	100	0.9861	150	0.9689	200	0.9520	250	0.9352	300	0.9187	350	0.9024	400	0.8864	450	0.8705
1	1.0200	51	1.0031	101	0.9857	151	0.9686	201	0.9516	251	0.9349	301	0.9184	351	0.9021	401	0.8861	451	0.8702
2	1.0204	52	1.0028	102	0.9854	152	0.9682	202	0.9513	252	0.9346	302	0.9181	352	0.9018	402	0.8857	452	0.8699
3	1.0201	53	1.0024	103	0.9851	153	0.0969	203	0.9509	253	0.9342	303	0.9177	353	0.9015	403	0.8854	453	0.8696
4	1.0197	54	1.0021	104	0.9847	154	0.9675	204	0.9506	254	0.9339	304	0.9174	354	0.9011	404	0.8851	454	0.8693
5	1.0194	55	1.0017	105	0.9844	155	0.9672	205	0.9503	255	0.9336	305	0.9171	355	0.9008	405	0.8848	455	0.8690
6	1.0190	56	1.0014	106	0.9840	156	0.9669	206	0.9499	256	0.9332	306	0.9167	356	0.9005	406	0.8845	456	0.8687
7	1.0186	57	1.0010	107	0.9837	157	0.9665	207	0.9496	257	0.9329	307	0.9164	357	0.9002	407	0.8841	457	0.8683
8	1.0183	58	1.0007	108	0.9833	158	0.9662	208	0.9493	258	0.9326	308	0.9161	358	0.8998	408	0.8838	458	0.8680
9	1.0179	59	1.0003	109	0.9830	159	0.9658	209	0.9489	259	0.9322	309	0.9158	359	0.8995	409	0.8835	459	0.8677
10	1.0176	60	1.0000	110	0.9826	160	0.9655	210	0.9486	260	0.9319	310	0.9154	360	0.8992	410	0.8832	460	0.8674
11	1.0172	61	0.9997	111	0.9823	161	0.9652	211	0.9483	261	0.9316	311	0.9151	361	0.9889	411	0.8829	461	0.8671
12	1.0169	62	0.9993	112	0.9819	162	0.9648	212	0.9479	262	0.9312	312	0.9148	362	0.8986	412	0.8826	462	0.8668
13	1.0165	63	0.9990	113	0.9816	163	0.9645	213	0.9476	263	0.9309	313	0.9145	363	0.8982	413	0.8822	463	0.8665
14	1.0162	64	0.9986	114	0.9813	164	0.9641	214	0.9472	264	0.9306	314	0.9141	364	0.8979	414	0.8819	464	0.8661
15	1.0158	65	0.9983	115	0.9809	165	0.9638	215	0.9469	265	0.9302	315	0.9138	365	0.8976	415	0.8816	465	0.8658
16	1.0155	66	0.9979	116	0.9806	166	0.9635	216	0.9466	266	0.9299	316	0.9135	366	0.8973	416	0.8813	466	0.8655
17	1.0151	67	0.9976	117	0.9802	167	0.9631	217	0.9462	267	0.9296	317	0.9132	367	0.8969	417	0.8810	467	0.8652
18	1.0148	68	0.9972	118	0.9799	168	0.9628	218	0.9459	268	0.9293	318	0.9128	368	0.8966	418	0.8806	468	0.8649
19	1.0144	69	0.9969	119	0.9795	169	0.9624	219	0.9456	269	0.9289	319	0.9125	369	0.8963	419	0.8803	469	0.8646
20	1.0141	70	0.9965	120	0.9792	170	0.9621	220	0.9452	270	0.9286	320	0.9122	370	0.8960	420	0.8800	470	0.8643
21	1.0137	71	0.9962	121	0.9788	171	0.9618	221	0.9449	271	0.9283	321	0.9118	371	0.8957	421	0.8797	471	0.8640
22	1.0133	72	0.9958	122	0.9785	172	0.9614	222	0.9446	272	0.9279	322	0.9115	372	0.8953	422	0.9794	472	0.8636
23	1.0130	73	0.9955	123	0.9782	173	0.9611	223	0.9442	273	0.9276	323	0.9112	373	0.8950	423	0.9791	473	0.8633
24	1.0126	74	0.9951	124	0.9778	174	0.9607	224	0.9439	274	0.9273	324	0.9109	374	0.8947	424	0.8787	474	0.8630
25	1.0123	75	0.9948	125	0.9775	175	0.9604	225	0.9436	275	0.9269	325	0.9105	375	0.8944	425	0.8784	475	0.8627
26	1.0119	76	0.9944	126	0.9771	176	0.9601	226	0.9432	276	0.9266	326	0.9102	376	0.8941	426	0.8781	476	0.8624
27	1.0116	77	0.9941	127	0.9768	177	0.9597	227	0.9429	277	0.9263	327	0.9099	377	0.8937	427	0.8778	477	0.8621
28	1.0112	78	0.9937	128	0.9764	178	0.9594	228	0.9426	278	0.9259	328	0.9096	378	0.8934	428	0.8775	478	0.8618
29	1.0109	79	0.9934	129	0.9761	179	0.9590	229	0.9422	279	0.9256	329	0.9092	379	0.8931	429	0.8772	479	0.8615
30	1.0105	80	0.9930	130	9.7558	180	0.9587	230	0.9419	280	0.9253	330	0.9089	380	0.8928	430	0.8768	480	0.8611
31	1.0102	81	0.9927	131	0.9754	181	0.9584	231	0.9416	281	0.9250	331	0.9086	381	0.8924	431	0.8765	481	0.8608
32	1.0098	82	0.9923	132	0.9751	182	0.9580	232	0.9412	282	0.9246	332	0.9083	382	0.8921	432	0.8762	482	0.8605
33	1.0095	83	0.9920	133	0.9747	183	0.9577	233	0.9409	283	0.9243	333	0.9079	383	0.8918	433	0.8759	483	0.8602
34	1.0091	84	0.9916	134	0.9744	184	0.9574	234	0.9405	284	0.9240	334	0.9076	384	0.8915	434	0.8756	484	0.8599
35	1.0088	85	0.9913	135	0.9740	185	0.9570	235	0.9402	285	0.9236	335	0.9073	385	0.8912	435	0.8753	485	0.8596
36	1.0084	86	0.9909	136	0.9737	186	0.9567	236	0.9399	286	0.9233	336	0.9070	386	0.8908	436	0.8749	486	0.8593
37	1.0081	87	0.9906	137	0.9734	187	0.9563	237	0.9395	287	0.9230	337	0.9066	387	0.8905	437	0.8746	487	0.8590
38	1.0077	88	0.9902	138	0.9730	188	0.9560	238	0.9392	288	0.9227	338	0.9063	388	0.8902	438	0.8743	488	0.8587
39	1.0074	89	0.9899	139	0.9727	189	0.9557	239	0.9389	289	0.9223	339	0.9060	389	0.8899	439	0.8740	489	0.8583
40	1.0070	90	0.9896	140	0.9723	190	0.9553	240	0.9385	290	0.9220	340	0.9057	390	0.8896	440	0.8737	490	0.8580
41	1.0067	91	0.9892	141	0.9720	191	0.9550	241	0.9382	291	0.9217	341	0.9053	391	0.8892	441	0.8734	491	0.8577
42	1.0063	92	0.9889	142	0.9716	192	0.9547	242	0.9379	292	0.9213	342	0.9050	392	0.8889	442	0.8731	492	0.8574
43	1.0060	93	0.9885	143	0.9713	193	0.9543	243	0.9375	293	0.9210	343	0.9047	393	0.8886	443	0.8727	493	0.8571
44	1.0056	94	0.9882	144	0.9710	194	0.9540	244	0.9372	294	0.9207	344	0.9044	394	0.8883	444	0.8724	494	0.8568
45	1.0053	95	0.9879	145	0.9706	195	0.9536	245	0.9369	295	0.9204	345	0.9040	395	0.8880	445	0.8721	495	0.8565
46	1.0049	96	0.9875	146	0.9703	196	0.9533	246	0.9365	296	0.9200	346	0.9037	396	0.8876	446	0.8718	496	0.8562
47	1.0046	97	0.9871	147	0.9699	197	0.9530	247	0.9362	297	0.9197	347	0.9034	397	0.8873	447	0.8715	497	0.8559
48	1.0042	98	0.9868	148	0.9696	198	0.9526	248	0.9359	298	0.9194	348	0.9031	398	0.8870	448	0.8712	498	0.8556
49	1.0038	99	0.9864	149	0.9693	199	0.9523	249	0.9356	299	0.9190	349	0.9028	399	0.8867	449	0.8709	499	0.8552